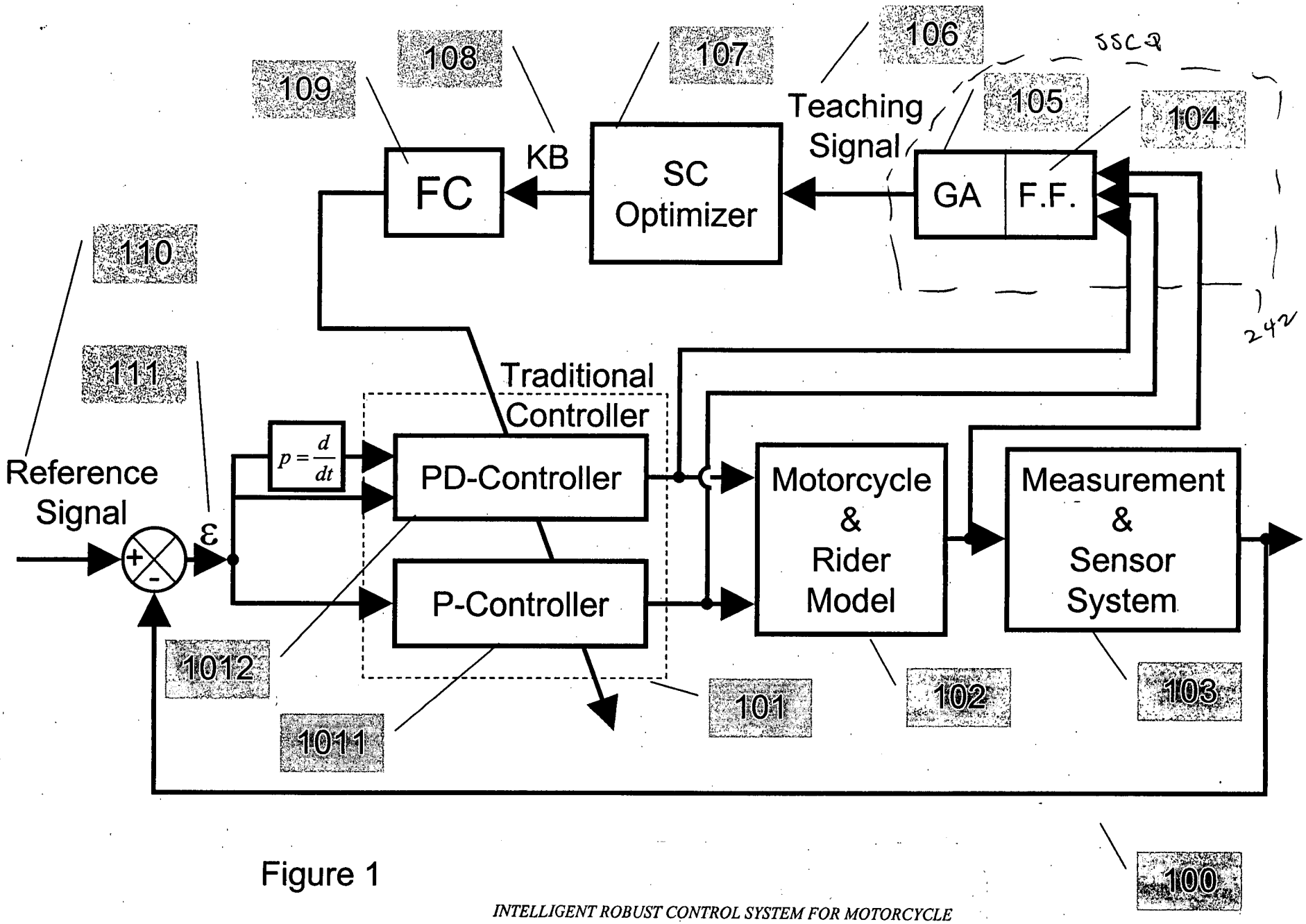
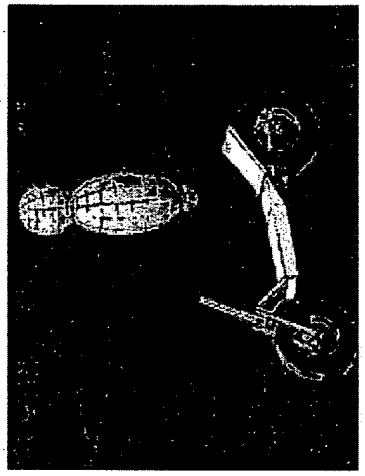
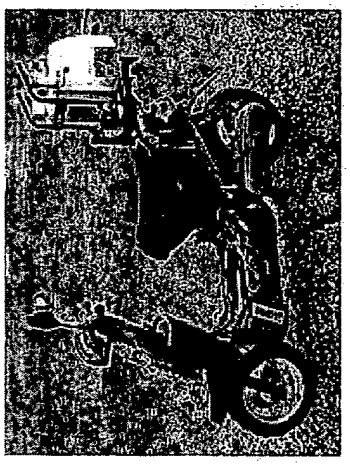

106
108
107
109
Teaching
Signal
105
104
KB
FC
SC
Optimizer
GA
F.F.
110
111
Traditional
Controller
$p = \frac{d}{dt}$
PD-Controller
Reference
Signal
ε
P-Controller
Motorcycle
&
Rider
Model
Measurement
&
Sensor
System
1012
1011
101
102
103
100

Figure 1



(b)



(a)

Figure 2.

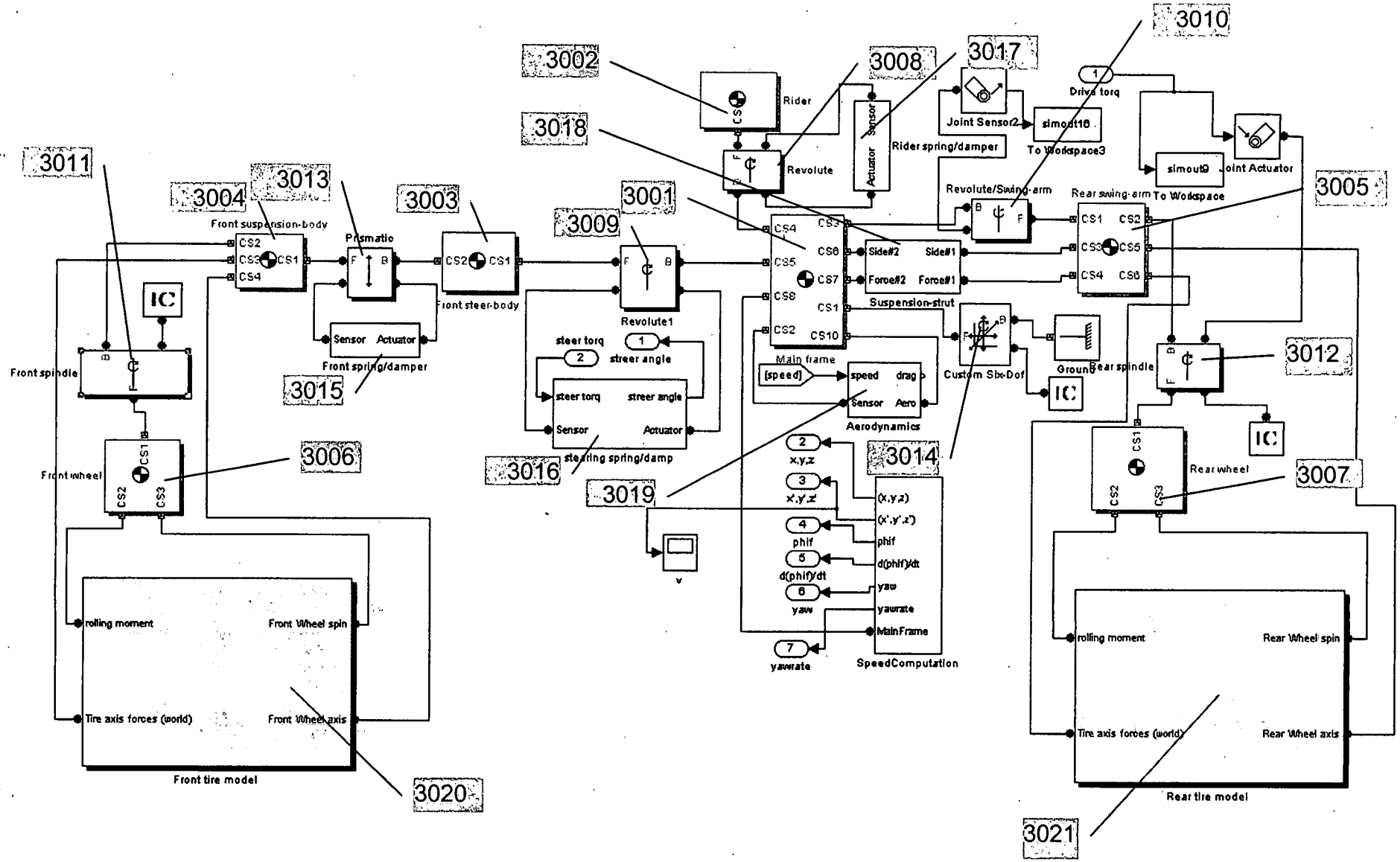


Figure 3

INTELLIGENT ROBUST CONTROL SYSTEM FOR MOTORCYCLE USING SOFT COMPUTING OPTIMIZER
Fujii et al.
Appl. No.: Unknown *Atty Docket: FY.51395US0A*

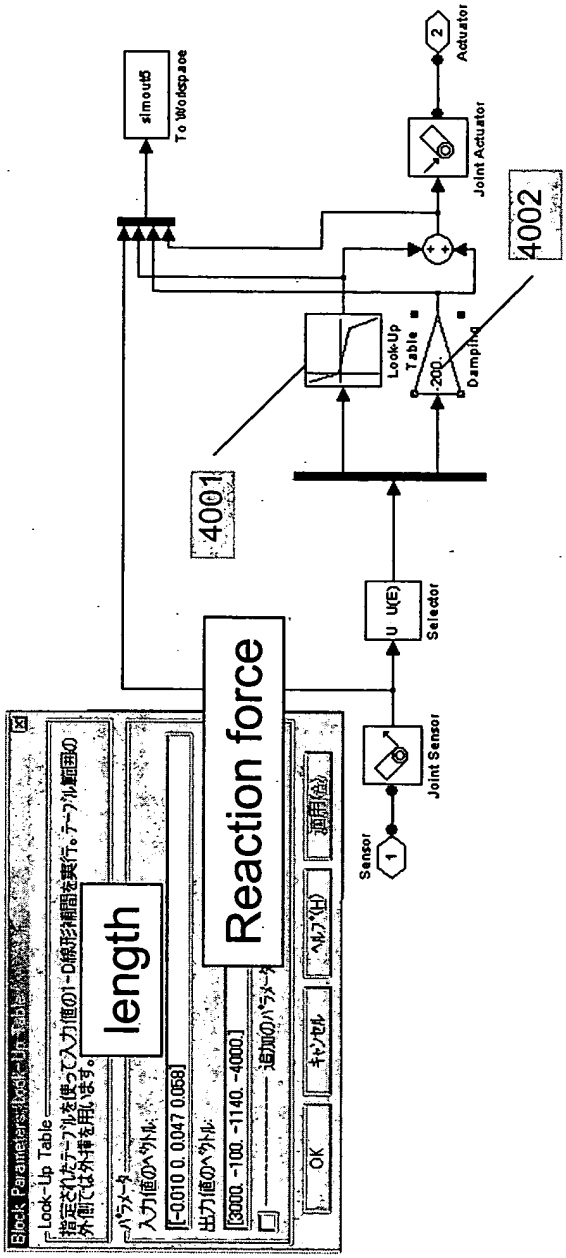

simout5
To Workspace
2
Actuator
Joint Actuator
4002
Look-Up Table
200.
Damping
4001
U U(E)
Selector
Joint Sensor
1
Sensor
Reaction force
length
Block Parameters: Look-Up Table
Look-Up Table
OK
キャンセル
適用(A)

Figure 4

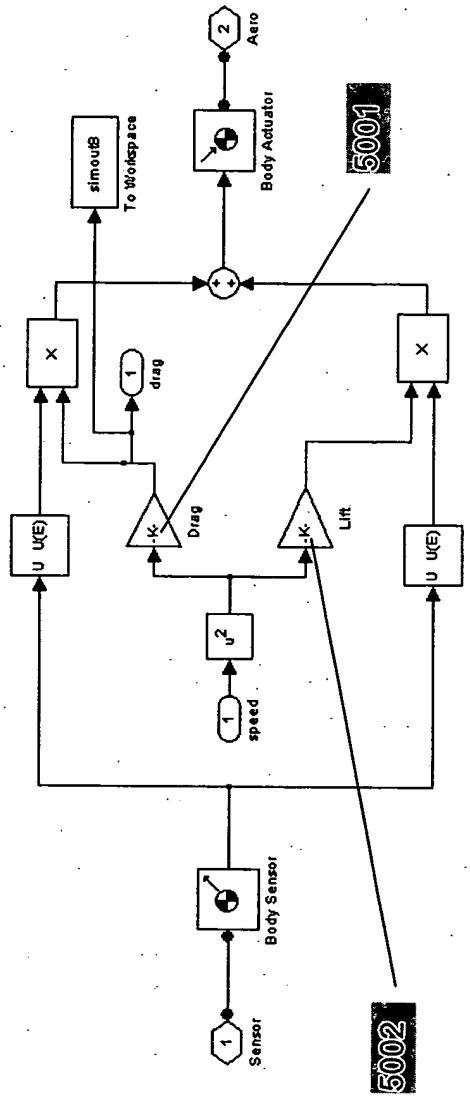

2
Aero
Body Actuator
5001
simout8
To Workspace
x
1
drag
x
-K-
Drag
-K-
Lift
U U(E)
U U(E)
u^2
1
speed
Body Sensor
1
Sensor
5002

Figure5

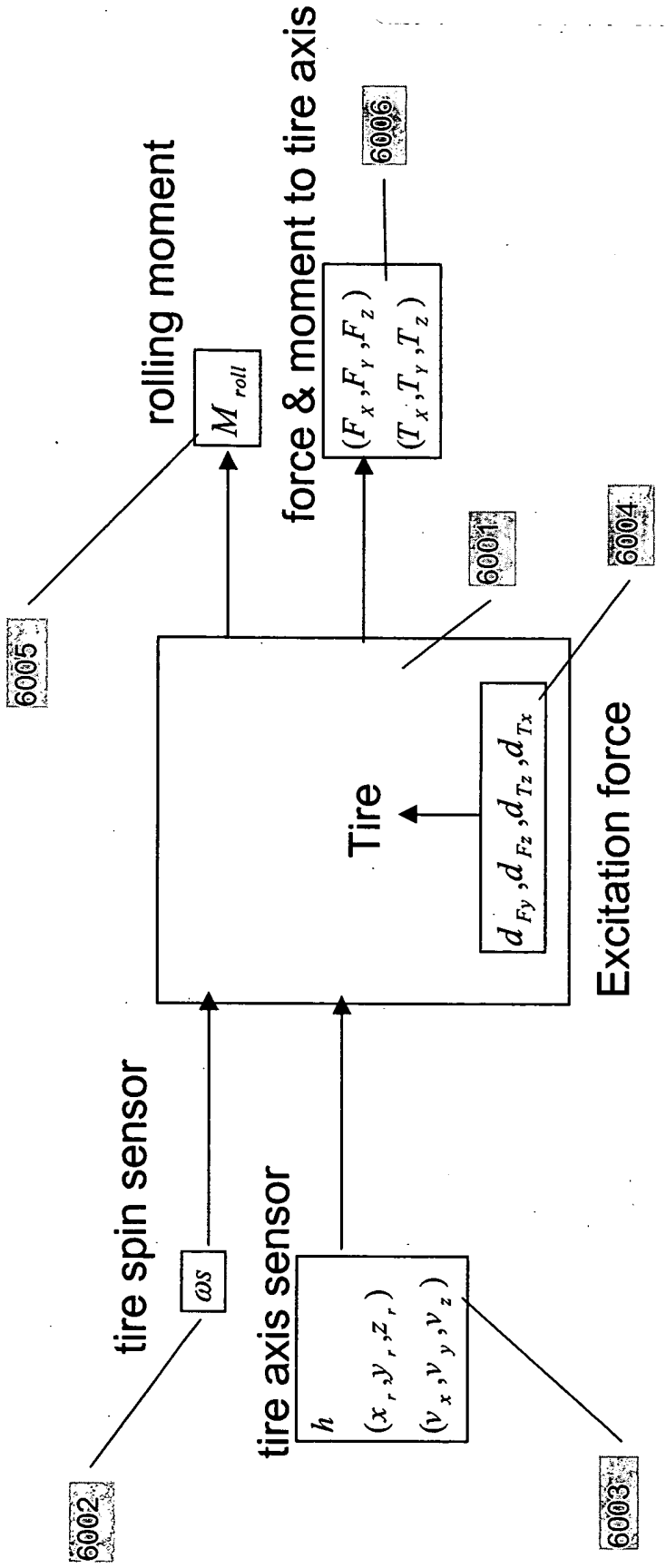

rolling moment
force & moment to tire axis
6006
6005
M_{roll}
(F_x, F_y, F_z)
(T_x, T_y, T_z)
6001
6004
Tire
$d_{Fy}, d_{Fz}, d_{Tz}, d_{Tx}$
Excitation force
tire spin sensor
tire axis sensor
ωs
h
(x_r, y_r, z_r)
(v_x, v_y, v_z)
6002
6003

Figure 6

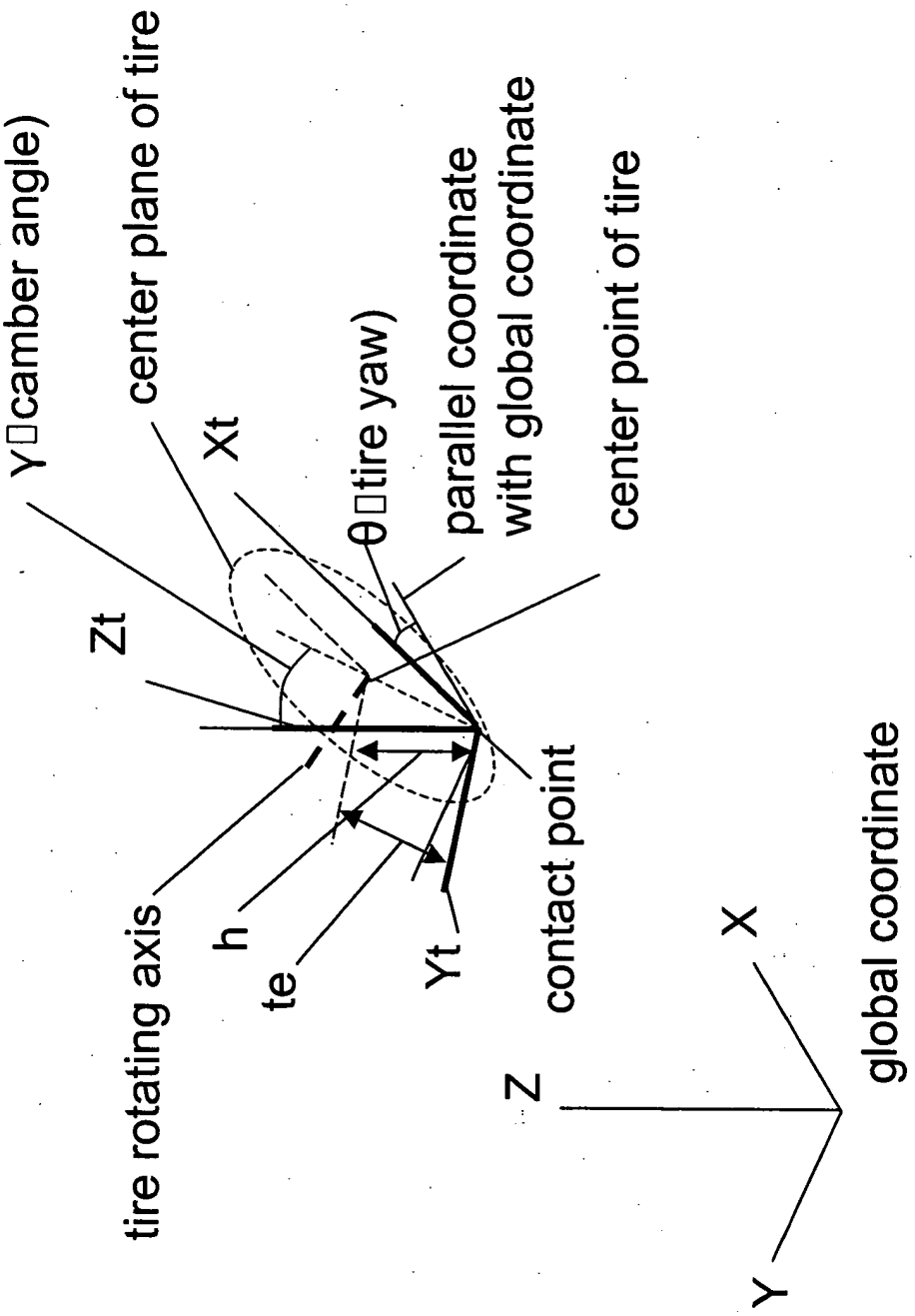

Y□camber angle)
center plane of tire
Xt
θ□tire yaw)
parallel coordinate
with global coordinate
center point of tire
Zt
tire rotating axis
h
te
Yt
contact point
Z
X
Y
global coordinate

Fig.7

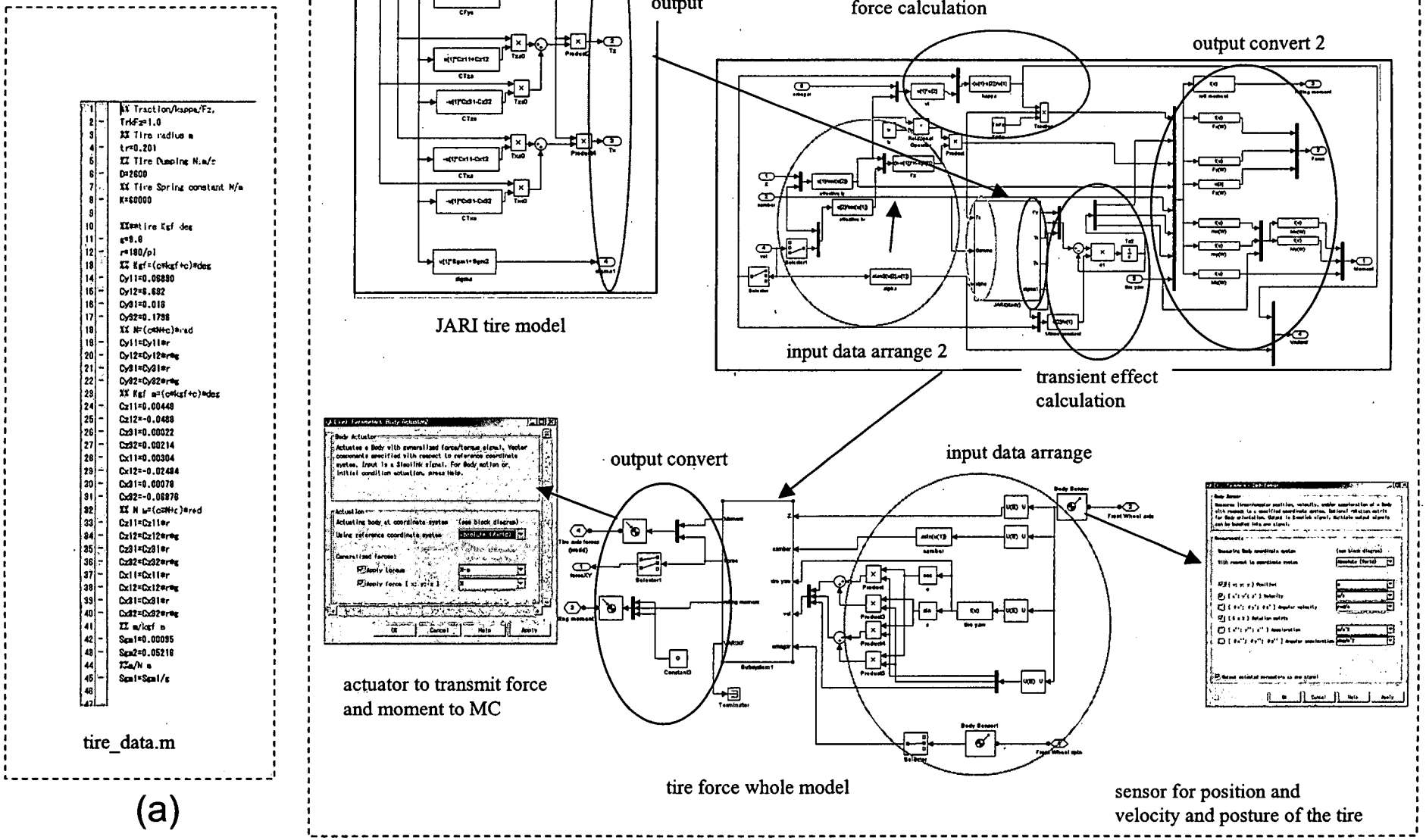

%% Traction/kappa/Fz,
TrkFz=1.0
%% Tire radius m
tr=0.201
%% Tire Damping N.m/r
D=2600
%% Tire Spring constant N/m
K=60000
%%=tire Kgf deg
g=9.8
r=180/pi
%% Kgf=(c*kgf*c)*deg
Cy11=0.06880
Cy12=8.682
Cy81=0.018
Cy82=0.1788
%% M=(c*M*c)*rad
Cy11=Cy11*r
Cy12=Cy12*r*g
Cy81=Cy81*r
Cy82=Cy82*r*g
%% Kgf m=(c*kgf*c)*deg
Cz11=0.00448
Cz12=-0.0488
Cz81=0.00022
Cz82=0.00214
Cx11=0.00304
Cx12=-0.02484
Cx81=0.00078
Cx82=-0.00878
%% M m=(c*M*c)*rad
Cz11=Cz11*r
Cz12=Cz12*r*g
Cz81=Cz81*r
Cz82=Cz82*r*g
Cx11=Cx11*r
Cx12=Cx12*r*g
Cx81=Cx81*r
Cx82=Cx82*r*g
%% m/kgf m
Scm1=0.00095
Scm2=0.05218
%%m/N m
Scm1=Scm1/g
tire_data.m
(a)
input
output
JARI tire model
forward and backward
force calculation
output convert 2
input data arrange 2
transient effect
calculation
output convert
input data arrange
actuator to transmit force
and moment to MC
tire force whole model
sensor for position and
velocity and posture of the tire
(b)

Figure 8.

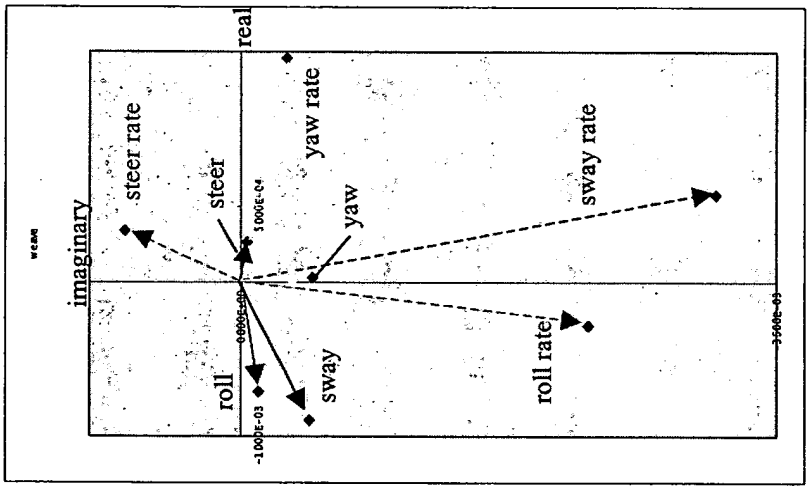

real
imaginary
steer rate
steer
yaw rate
yaw
sway rate
roll
sway
roll rate

Fig.9

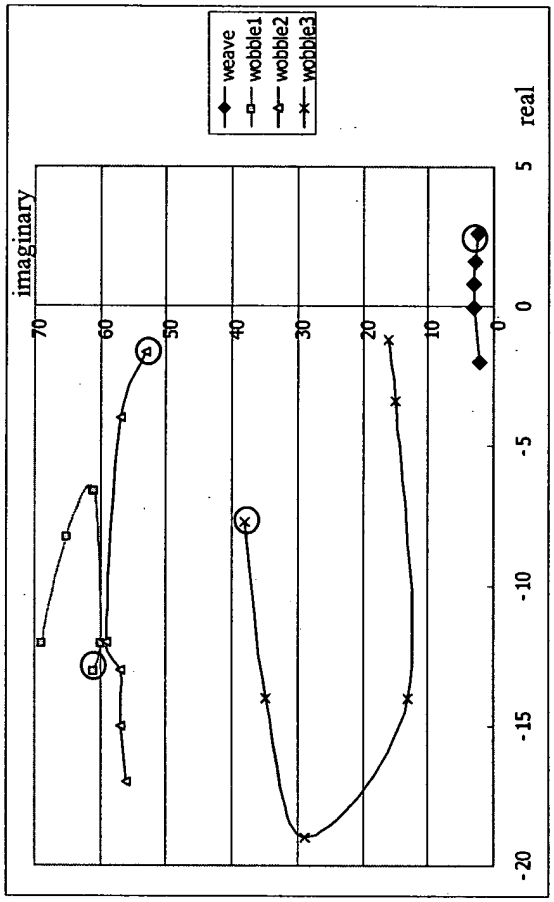

weave
wobble1
wobble2
wobble3
imaginary
real
70
60
50
40
30
20
10
0
5
0
-5
-10
-15
-20

Fig.10

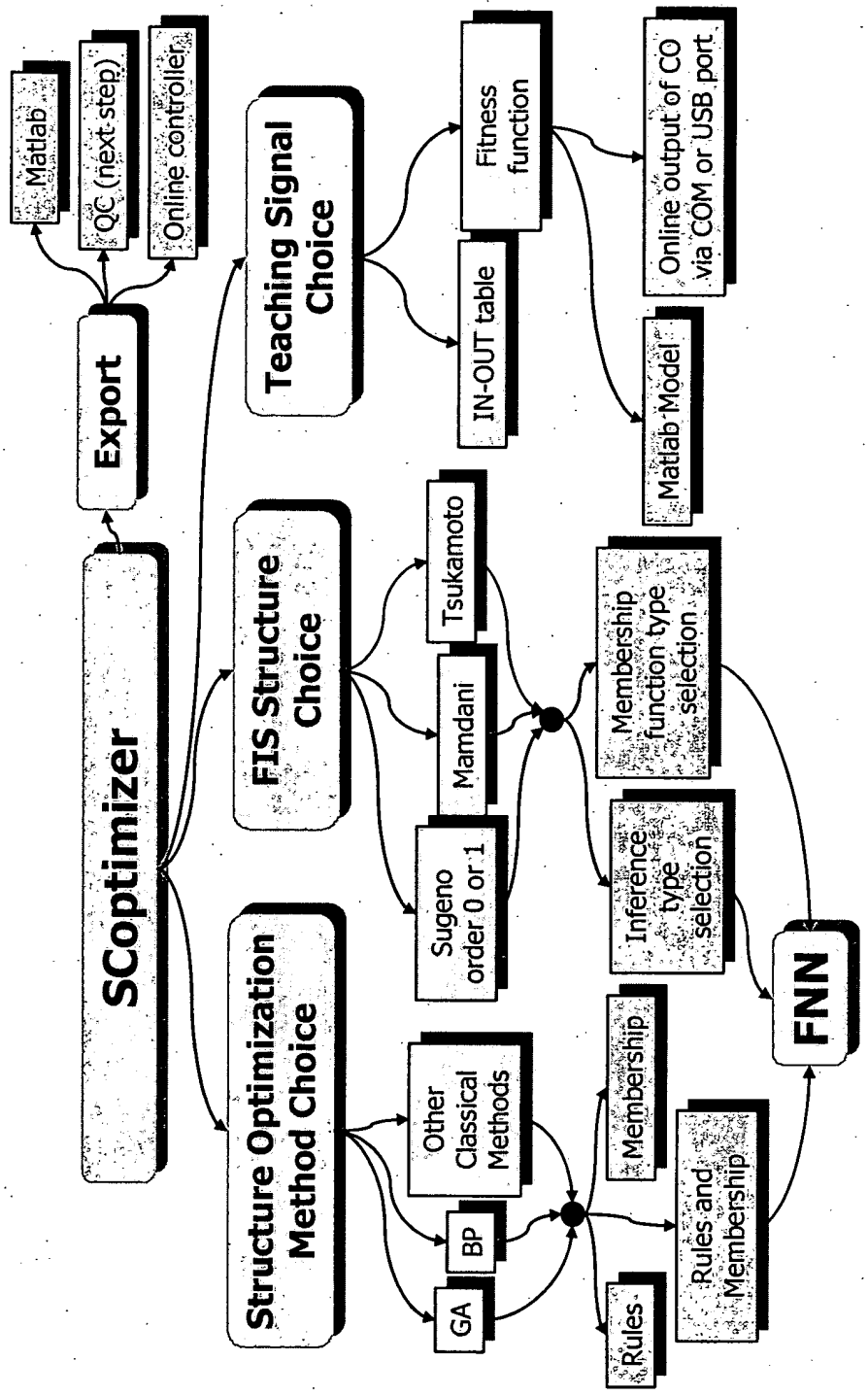

SCoptimizer
Export
Matlab
QC (next step)
Online controller
Teaching Signal Choice
Fitness function
IN-OUT table
Online output of CO via COM or USB port
Matlab Model
FIS Structure Choice
Tsukamoto
Mamdani
Sugeno order 0 or 1
Membership function type selection
Inference type selection
Structure Optimization Method Choice
Other Classical Methods
BP
GA
Membership
Rules
Rules and Membership
FNN

Figure 11.

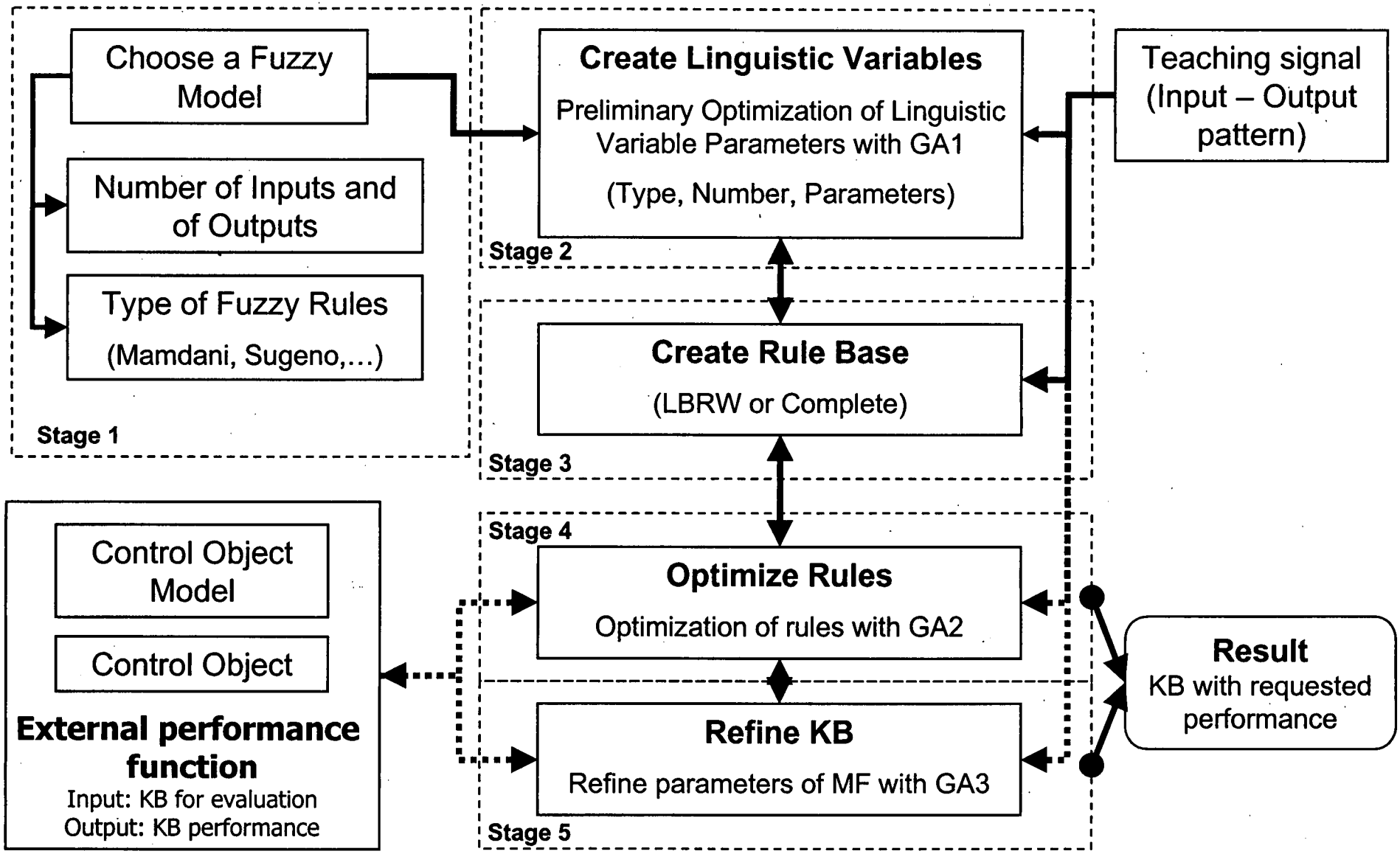

Choose a Fuzzy Model
Number of Inputs and of Outputs
Type of Fuzzy Rules
(Mamdani, Sugeno,...)
Stage 1
Create Linguistic Variables
Preliminary Optimization of Linguistic Variable Parameters with GA1
(Type, Number, Parameters)
Stage 2
Teaching signal (Input – Output pattern)
Create Rule Base
(LBRW or Complete)
Stage 3
Stage 4
Optimize Rules
Optimization of rules with GA2
Refine KB
Refine parameters of MF with GA3
Stage 5
Result
KB with requested performance
Control Object Model
Control Object
External performance function
Input: KB for evaluation
Output: KB performance

Figure 12A

Figure 12B

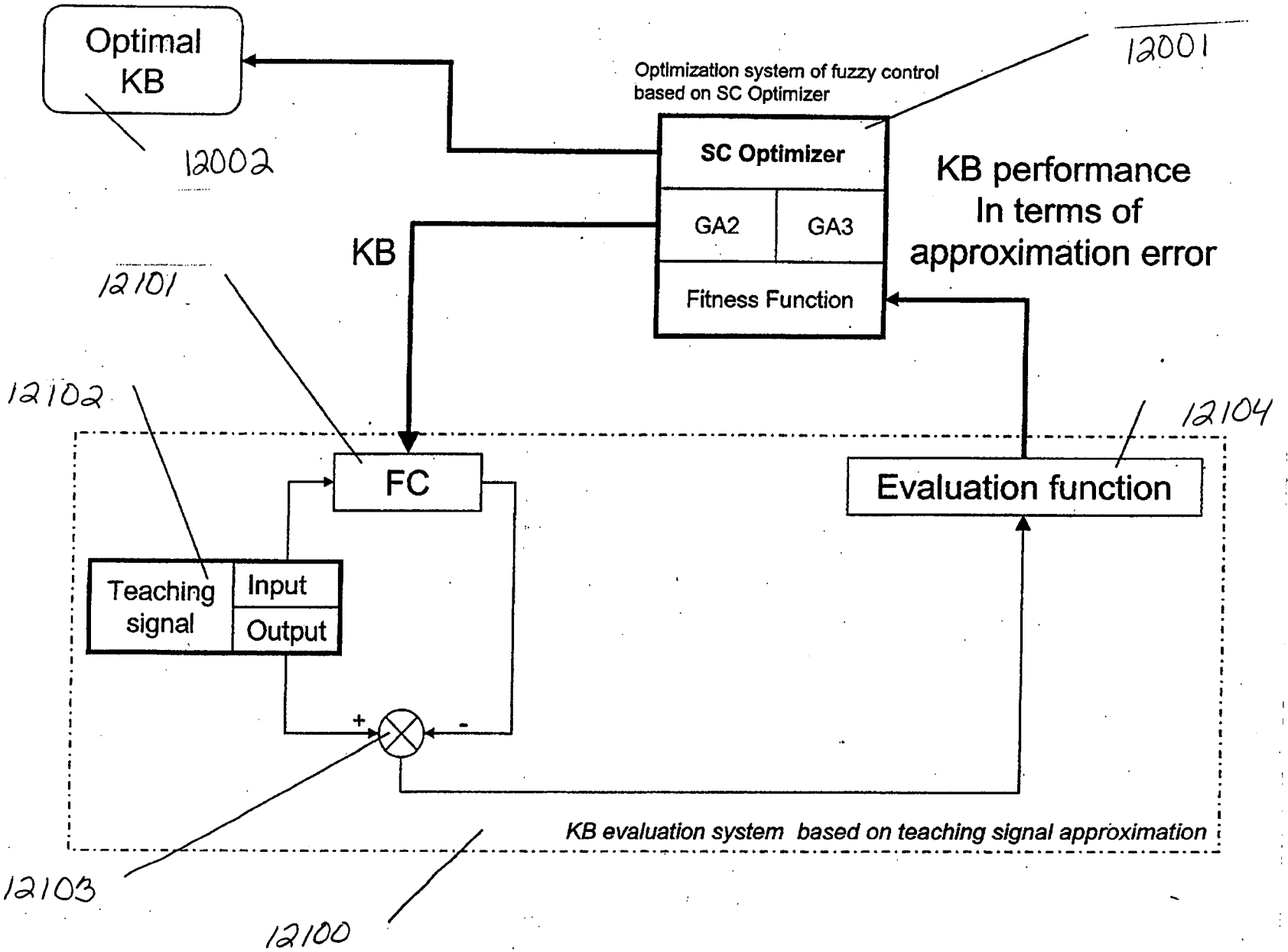
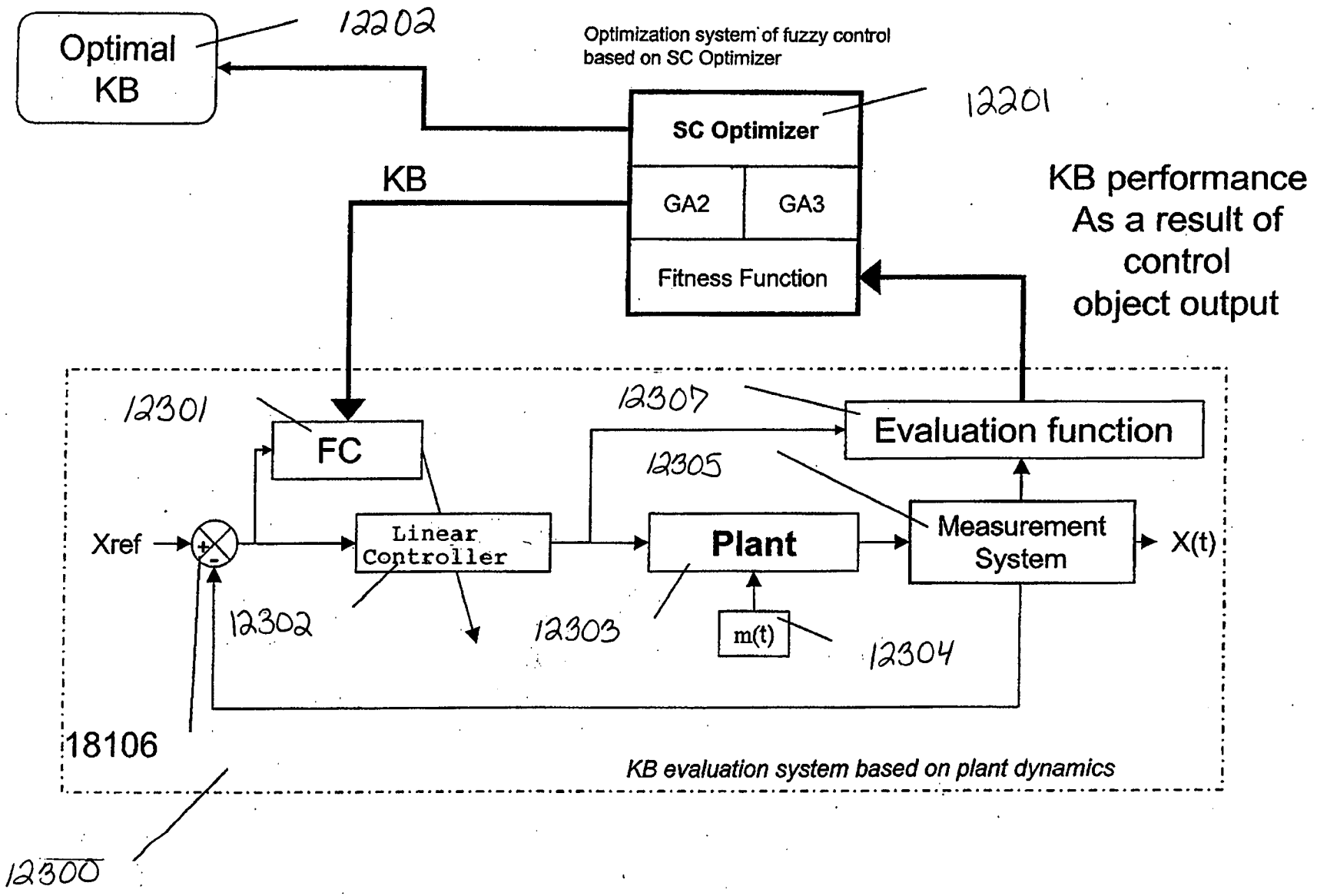

Optimal KB
12002
12001
Optimization system of fuzzy control based on SC Optimizer
SC Optimizer
GA2
GA3
Fitness Function
KB performance In terms of approximation error
KB
12101
12102
12104
FC
Evaluation function
Teaching signal
Input
Output
+
-
KB evaluation system based on teaching signal approximation
12103
12100

Figure 12C


Optimal KB
12202
Optimization system of fuzzy control based on SC Optimizer
SC Optimizer
12201
KB
GA2
GA3
Fitness Function
KB performance As a result of control object output
12301
FC
12307
Evaluation function
12305
Xref
Linear Controller
Plant
Measurement System
X(t)
12302
12303
m(t)
12304
18106
KB evaluation system based on plant dynamics
12300

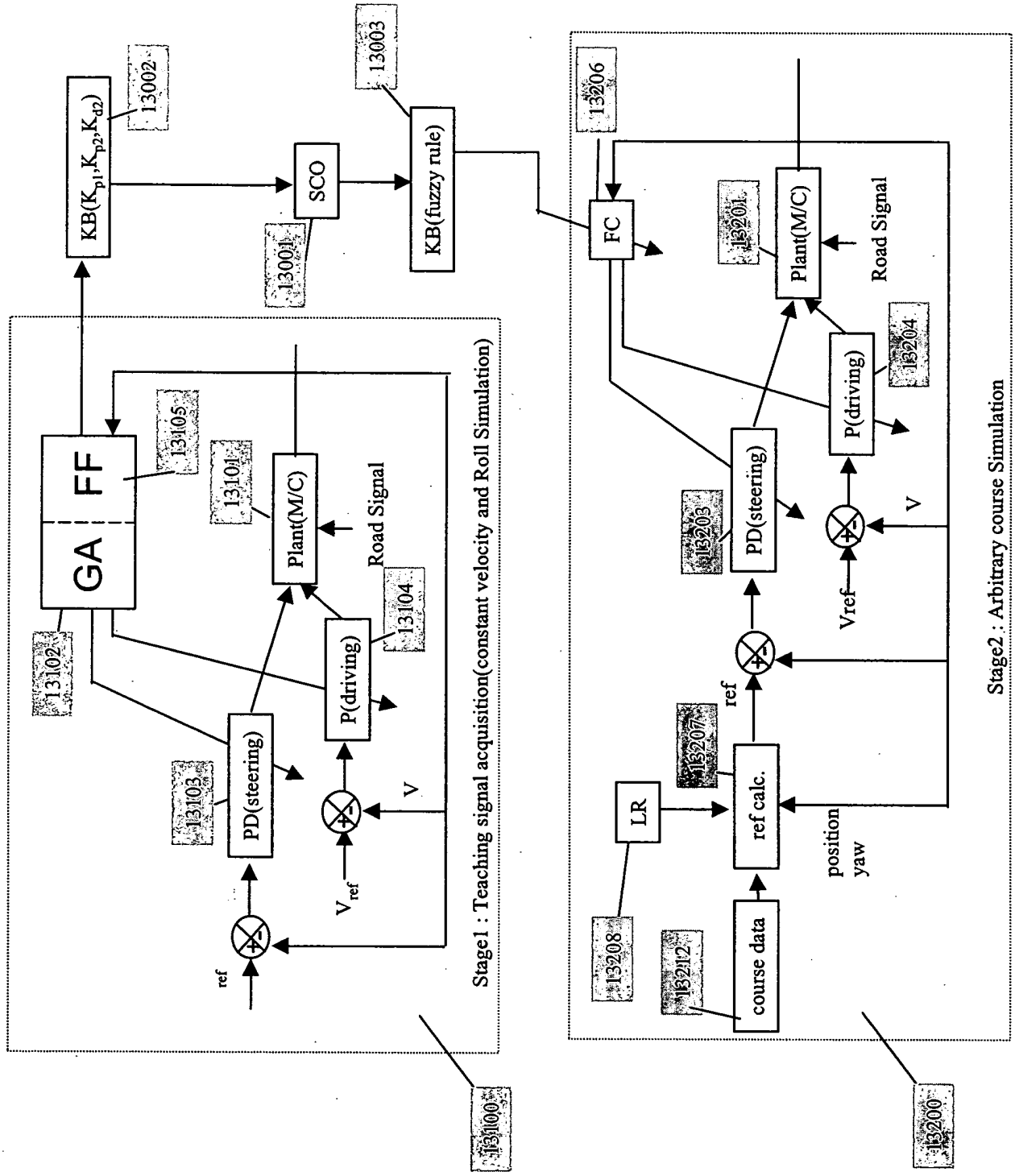

KB(K_{p1},K_{p2},K_{d2})
13002
SCO
13001
13003
KB(fuzzy rule)
GA
FF
13102
13105
13101
Plant(M/C)
Road Signal
13104
P(driving)
PD(steering)
13103
ref
V_{ref}
V
Stage1 : Teaching signal acquisition(constant velocity and Roll Simulation)
13100
13206
FC
13201
Plant(M/C)
Road Signal
13204
P(driving)
13203
PD(steering)
V
Vref
ref
13207
LR
ref calc.
position
yaw
13208
13212
course data
Stage2 : Arbitrary course Simulation
13200

Figure 13

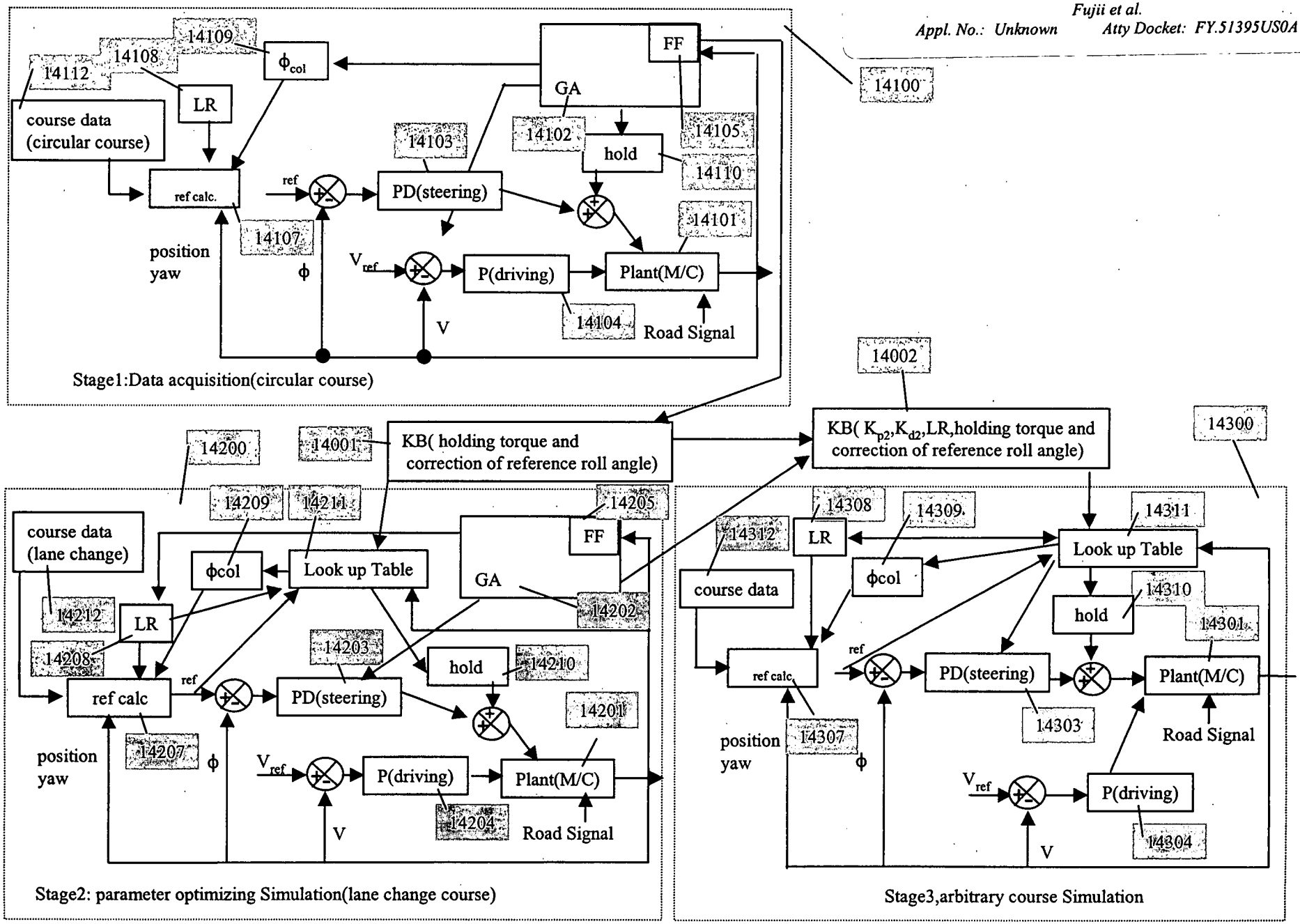

14100
14109
14108
14112
ϕ_{col}
LR
course data (circular course)
FF
GA
14105
14102
hold
14110
14103
ref calc.
ref
PD(steering)
14101
14107
position
yaw
ϕ
V_{ref}
P(driving)
Plant(M/C)
14104
V
Road Signal
Stage1:Data acquisition(circular course)
14002
14001
KB(holding torque and correction of reference roll angle)
KB(K_{p2},K_{d2},LR,holding torque and correction of reference roll angle)
14300
14200
14209
14211
14205
course data (lane change)
FF
ϕcol
Look up Table
GA
14212
LR
14202
14208
14203
hold
14210
ref calc
ref
PD(steering)
14201
14207
position
yaw
ϕ
V_{ref}
P(driving)
Plant(M/C)
14204
V
Road Signal
Stage2: parameter optimizing Simulation(lane change course)
14308
14309
14311
14312
LR
Look up Table
course data
ϕcol
14310
hold
14301
ref calc
ref
PD(steering)
Plant(M/C)
14303
Road Signal
position
yaw
14307
ϕ
V_{ref}
P(driving)
14304
V
Stage3,arbitrary course Simulation

Figure 14

Length of reference(LR)
Deviation : y
Present Position
Ref. Route
Trajectory
length of reference(LR) and deviation(y)
(b)
ref
g
Required Roll Angle
Watch Distance
Vehicle Velocity
Deviation
Gravity Acceleration
Required Acceleration
Reference roll angle
(a)

Figure 15

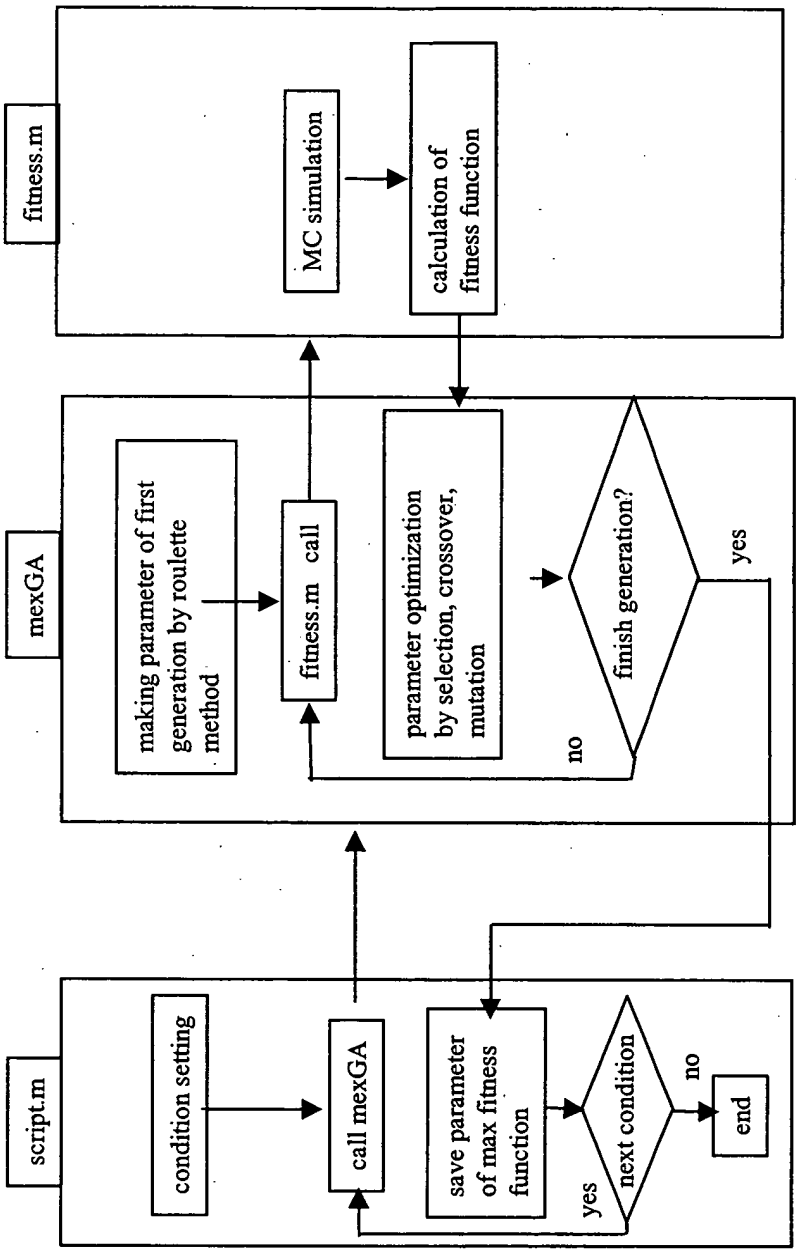

fitness.m
MC simulation
calculation of fitness function
mexGA
making parameter of first generation by roulette method
fitness.m call
parameter optimization by selection, crossover, mutation
finish generation?
yes
no
script.m
condition setting
call mexGA
save parameter of max fitness function
next condition
yes
no
end

Fig.16

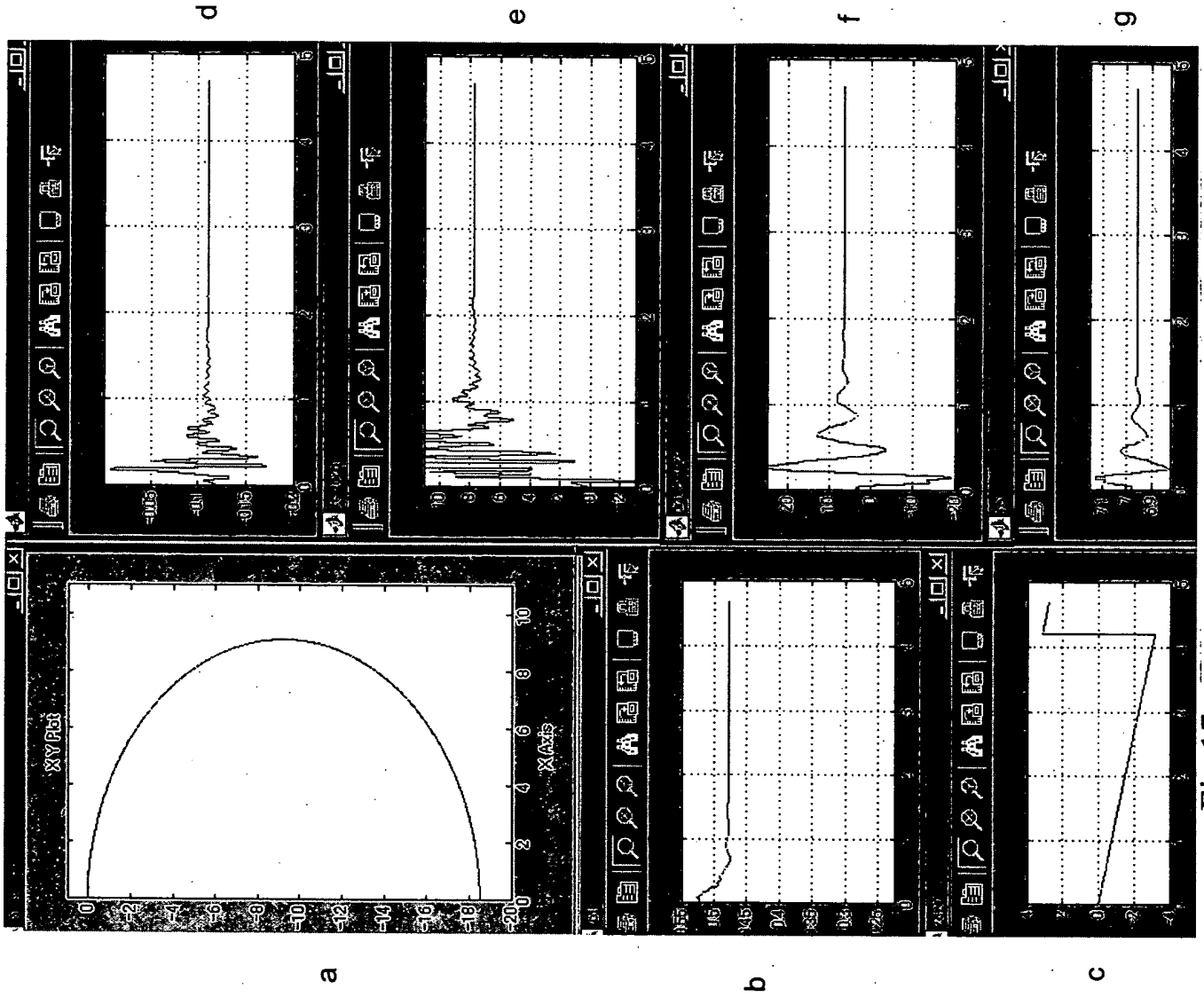


Fig.17 :

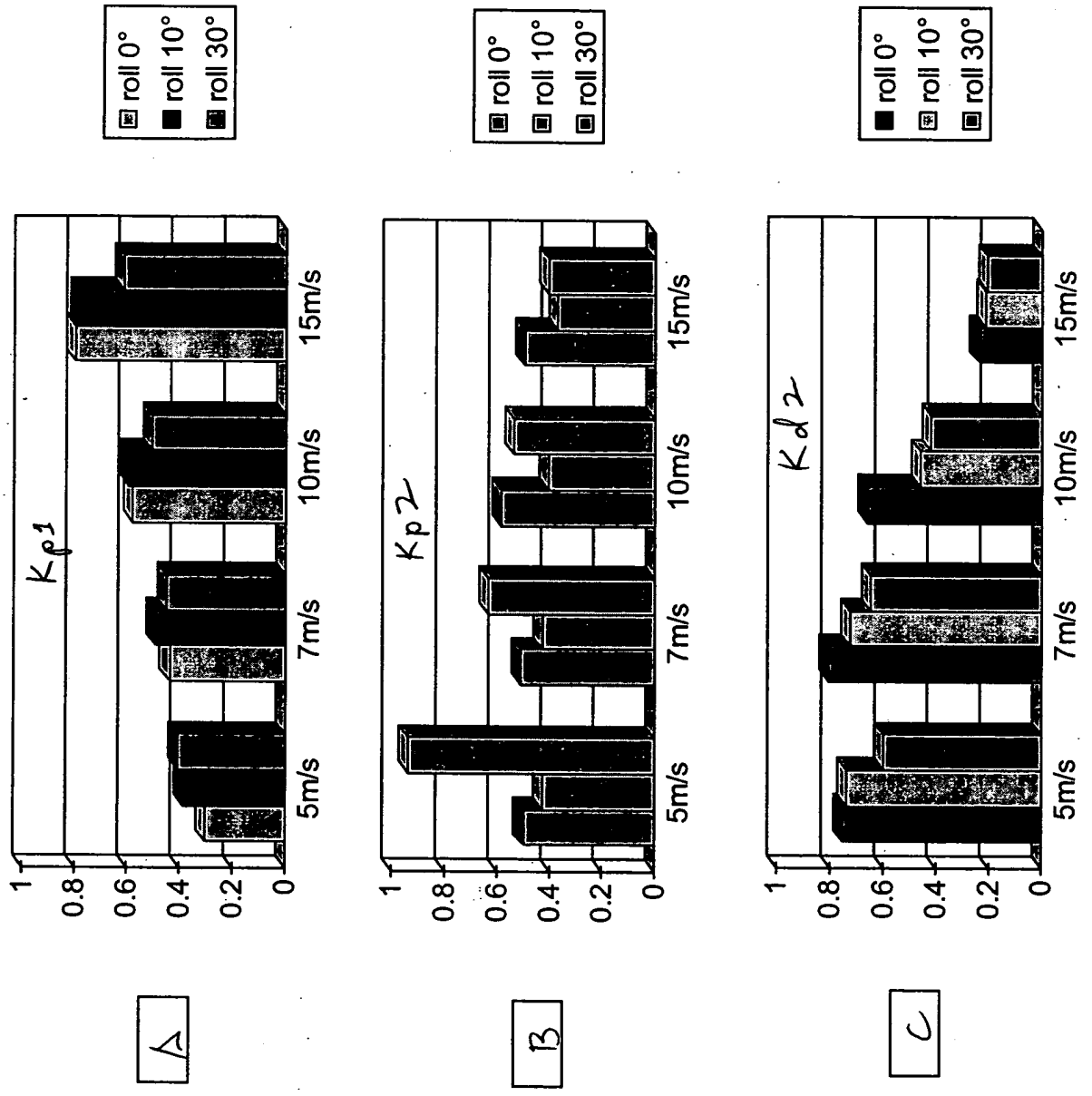

roll 0°
roll 10°
roll 30°
Kp1
Kp2
Kd2
1
0.8
0.6
0.4
0.2
0
5m/s
7m/s
10m/s
15m/s
A
B
C

Fig.18

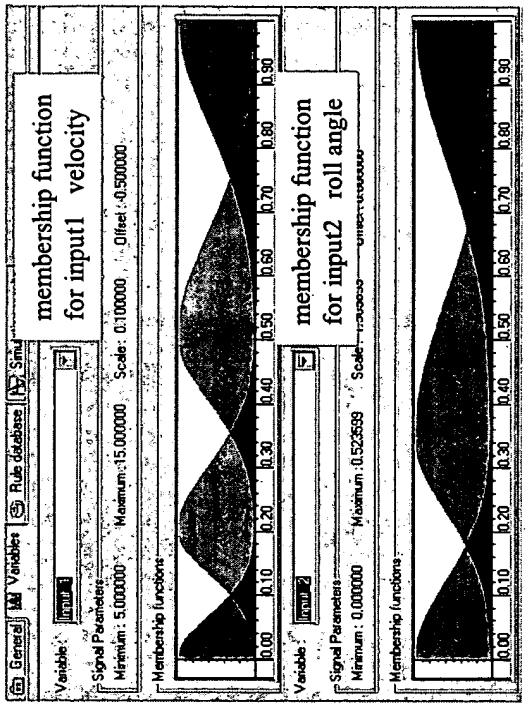
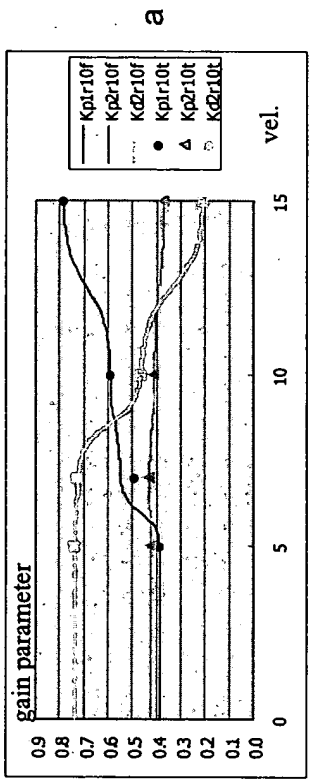
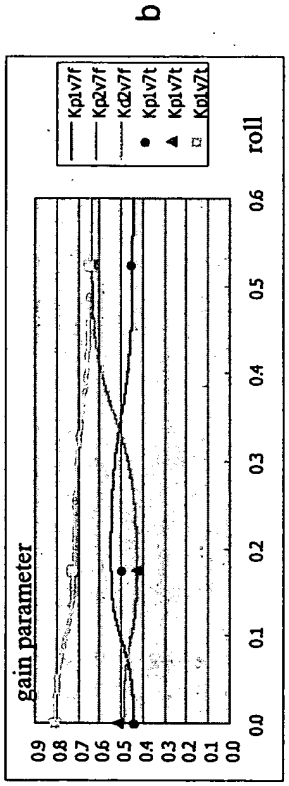

General
Variables
Rule database
Simu
Variable:
input1
Signal Parameters
Minimum : 5.000000
Maximum : 15.000000
Scale: 0.100000
Offset : 0.500000
Membership functions
membership function
for input1 velocity
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Variable:
input2
Signal Parameters
Minimum : 0.000000
Maximum : 0.523599
Membership functions
membership function
for input2 roll angle
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90

Fig.19



Lines:Fuzzy controller output(roll 10deg.)
point: Teaching signal(roll 10deg.)



Lines:Fuzzy controller output(vel.7m/s)
point: Teaching signal(vel.7m/s)

Fig.20

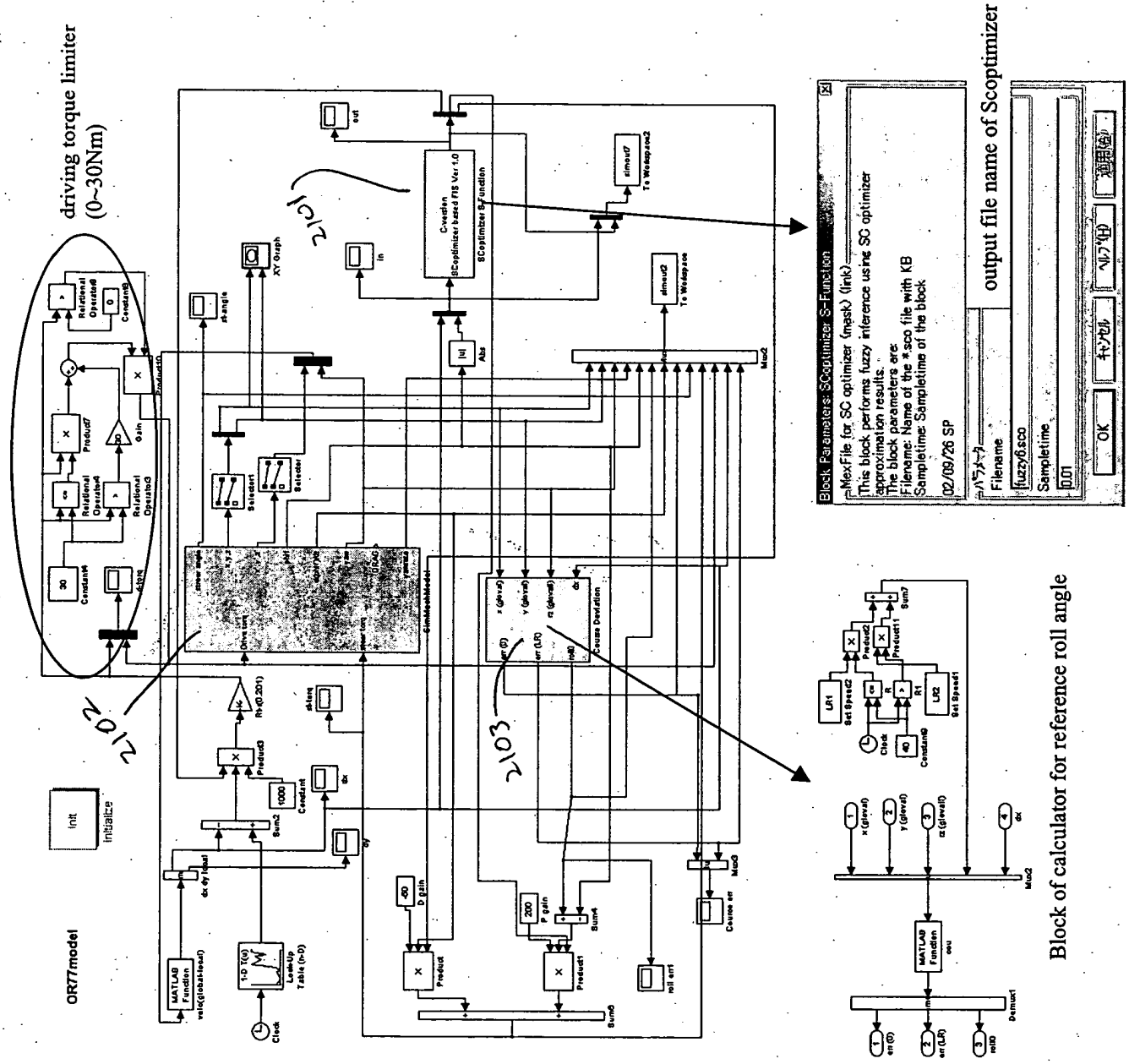
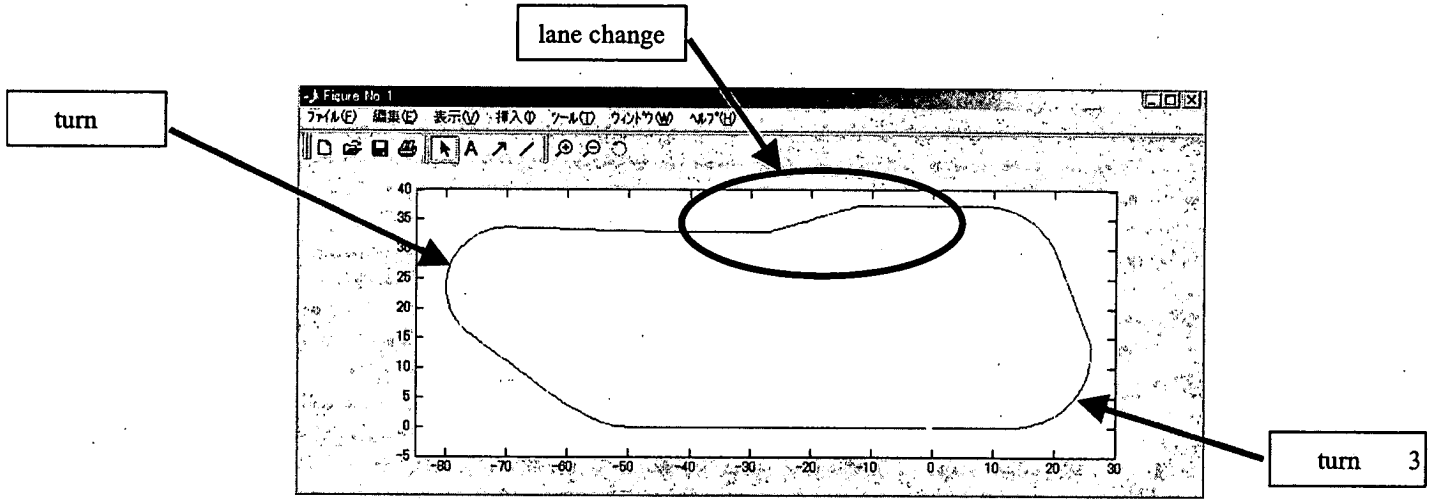
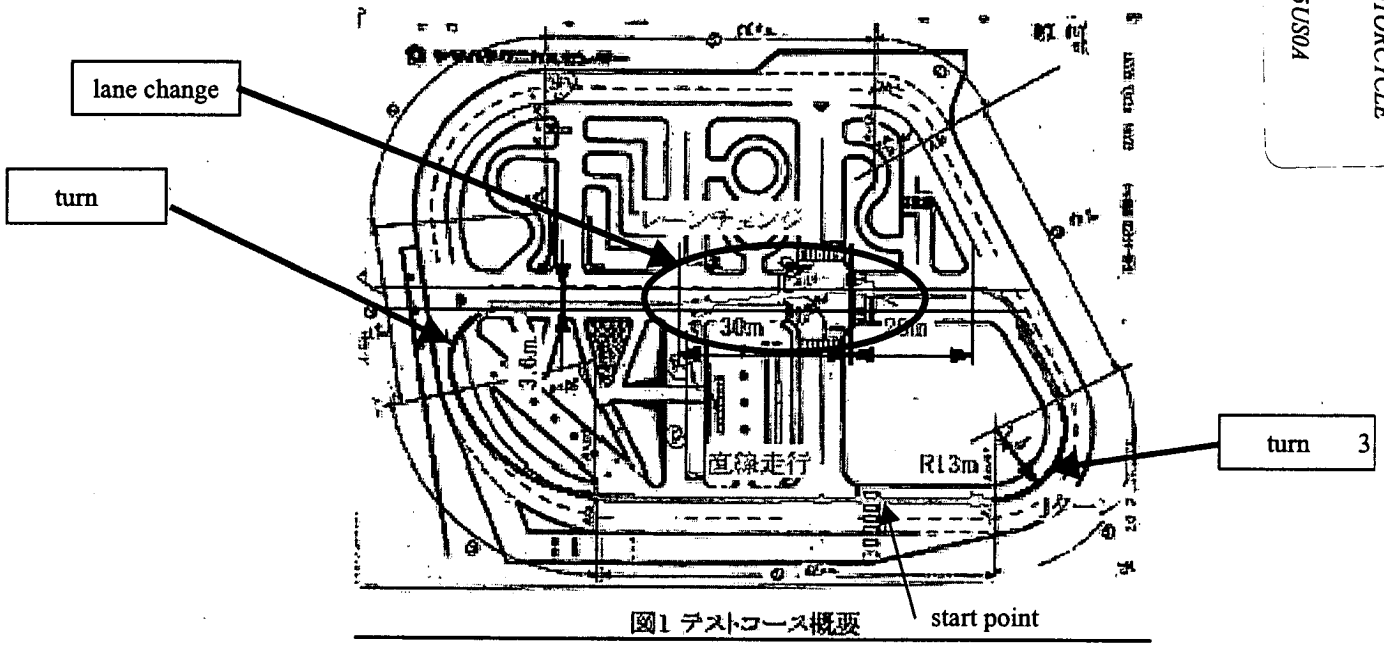

driving torque limiter
(0~30Nm)
output file name of Scoptimizer
Block of calculator for reference roll angle
2101
2102
2103
2107
OR7/model
Init
Initialize
Block Parameters: SCoptimizer S-Function
MexFile (or SC optimizer (mask) (link)
This block performs fuzzy inference using SC optimizer approximation results.
The block parameters are:
Filename: Name of the *.sco file with KB
Sampletime: Sampletime of the block
02/09/26 SP
パラメータ
Filename
fuzzy6.sco
Sampletime
0.01
OK

Figure21



(a) the simulation course



(b) the map of the actual test course

Figure 22

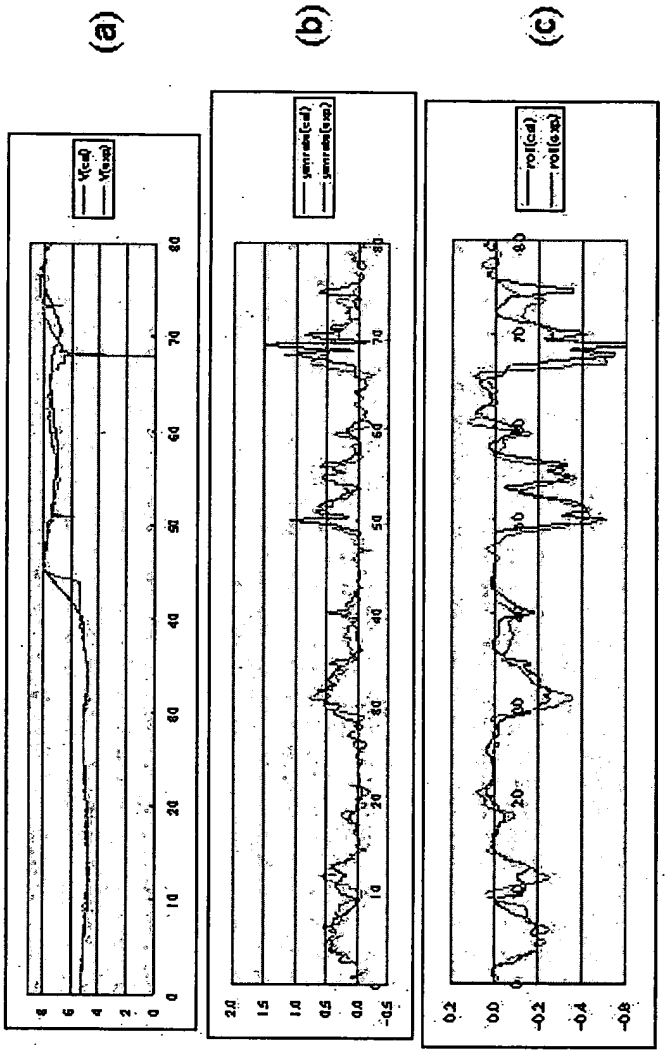


Fig.23 (a-c from above)

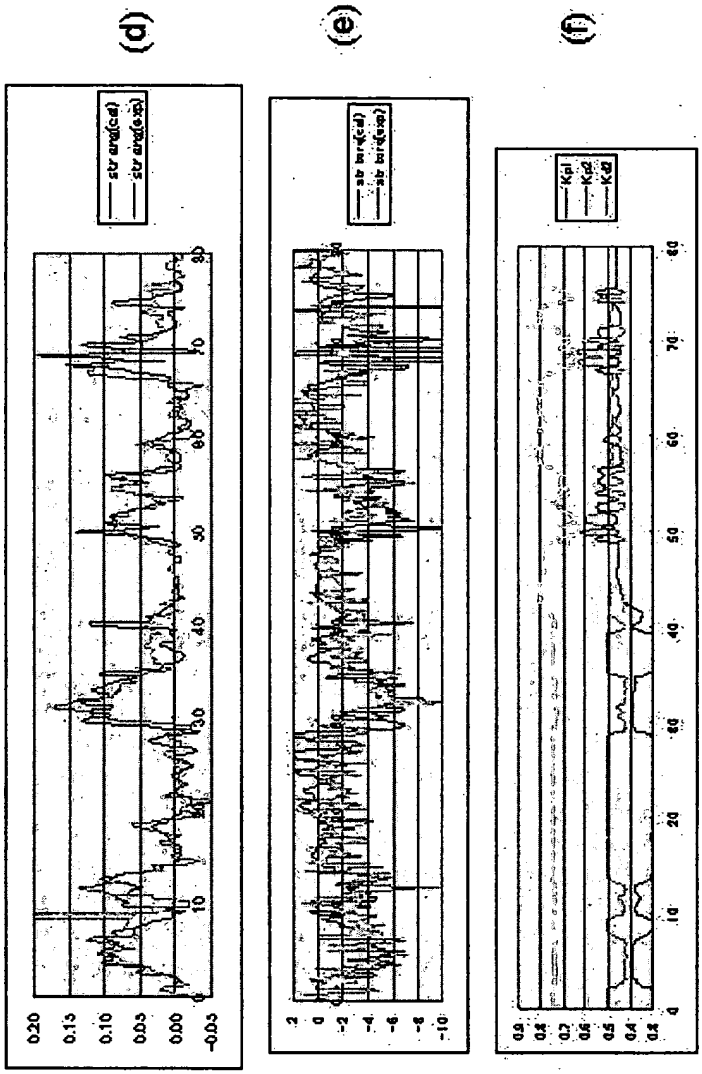


Fig.23 (d-f from above)

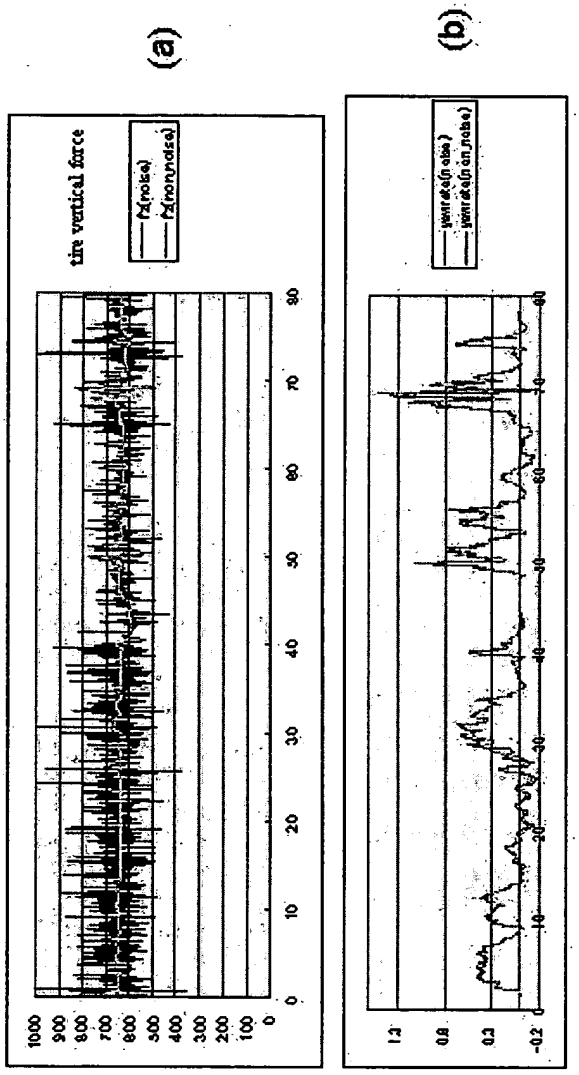


Fig.24 (a-b from above)

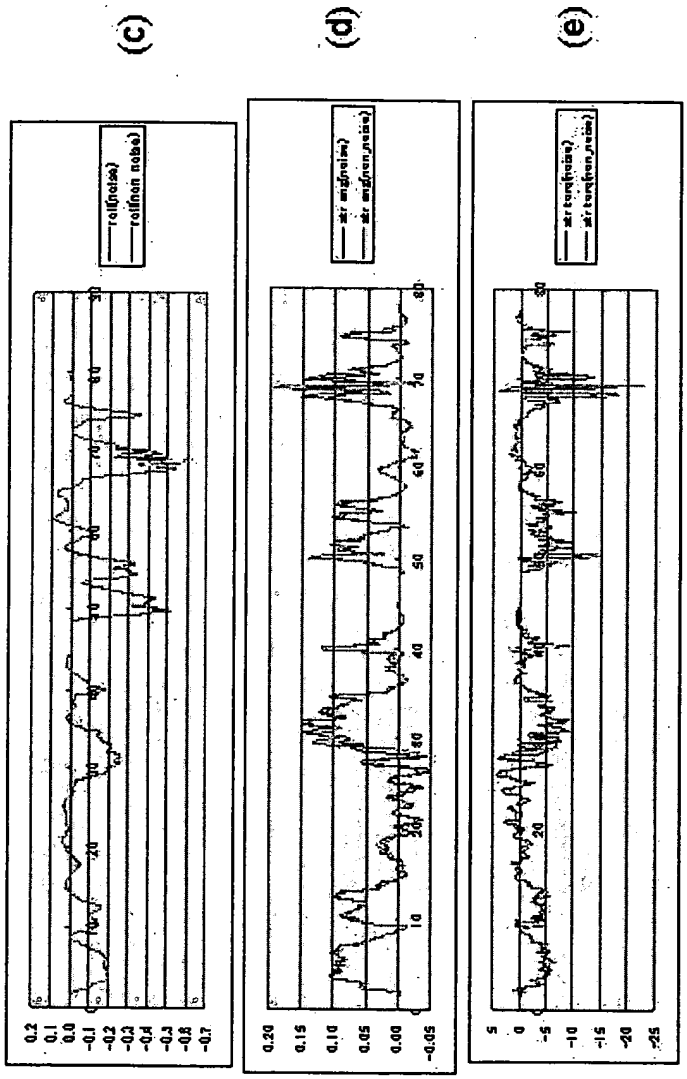


Fig.24 (c-e from above)

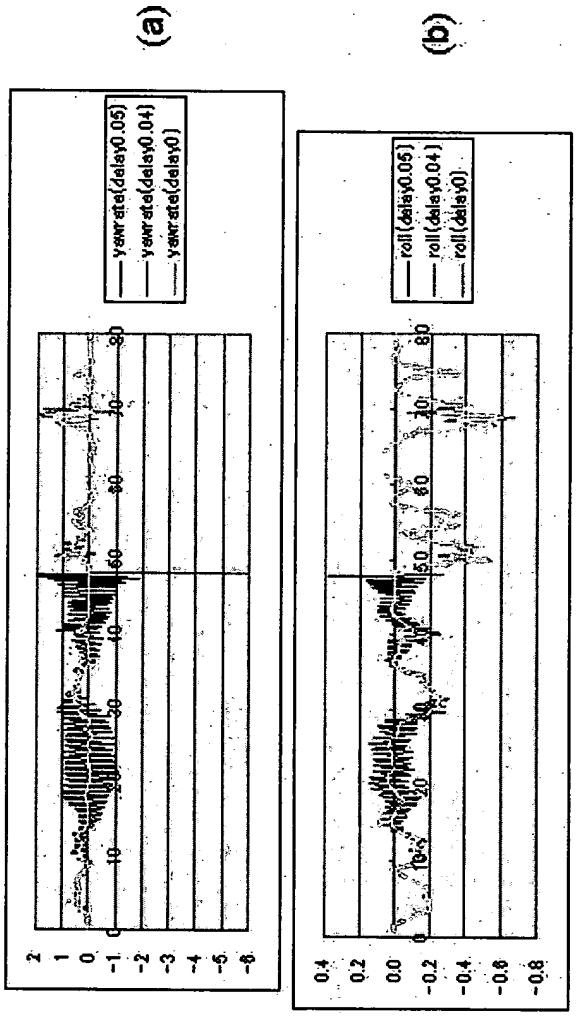


Fig.25(a-b from above)

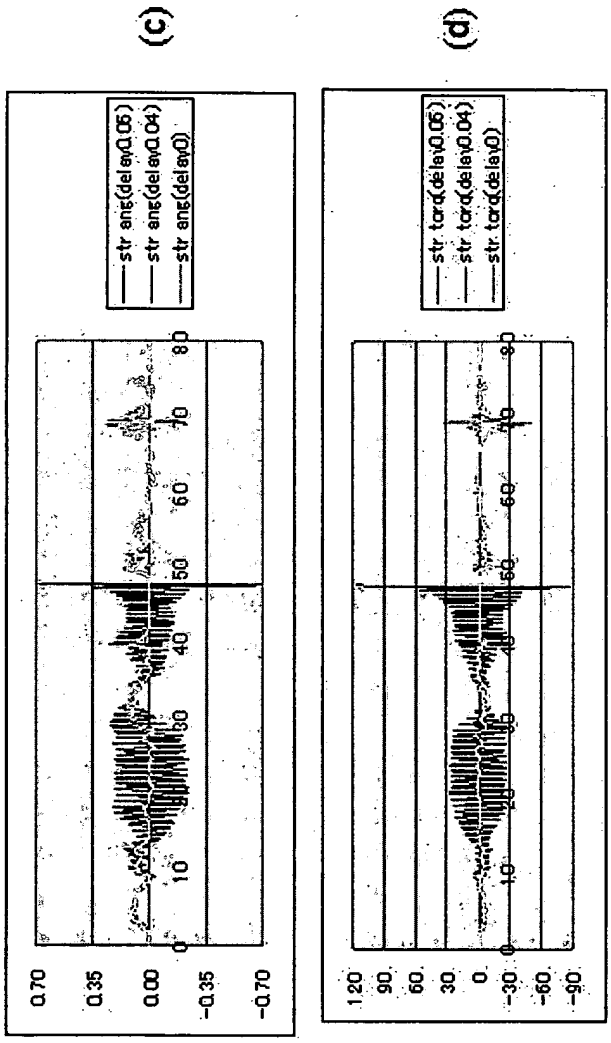


Fig.25 (c-d from above)

(a) Relation between deviation of course at length of reference and turning radius

(b) Process of making feed forward rider model

Figure 26

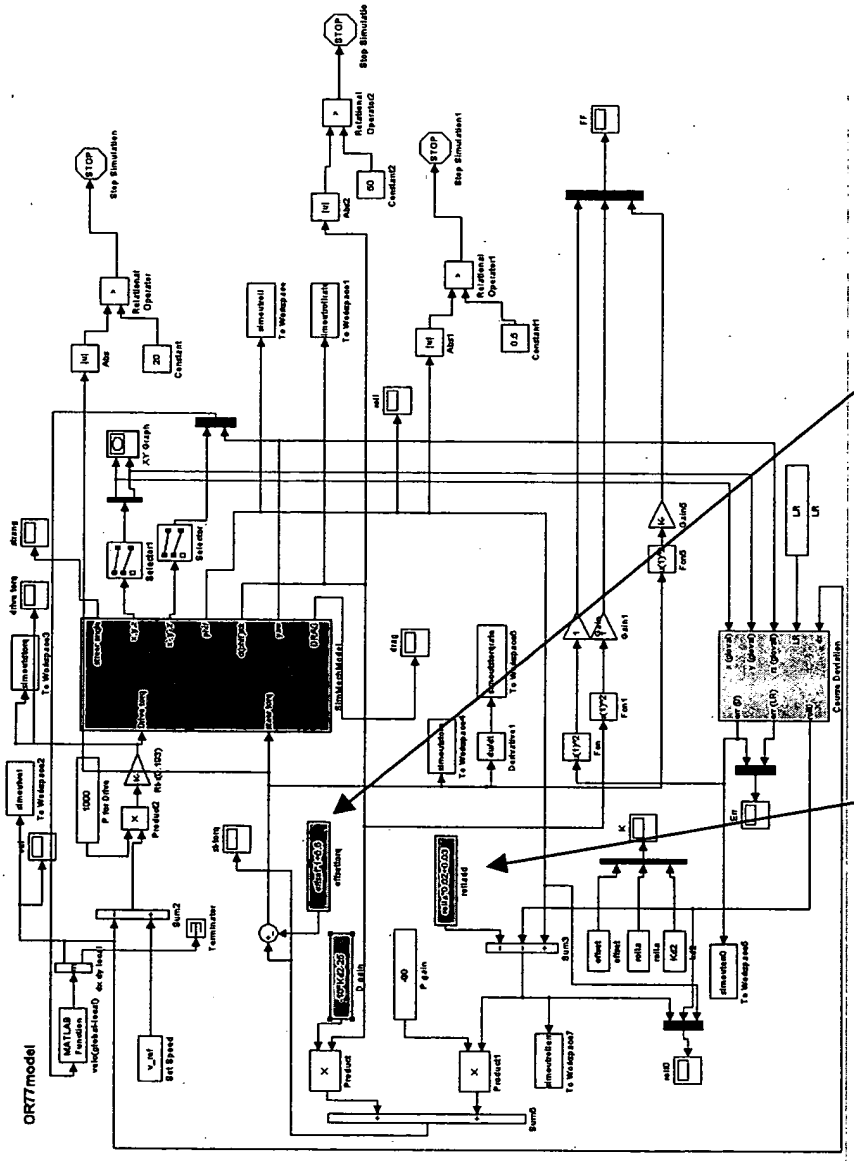

holding torque
correction of reference roll angle
OR77model

Fig.27

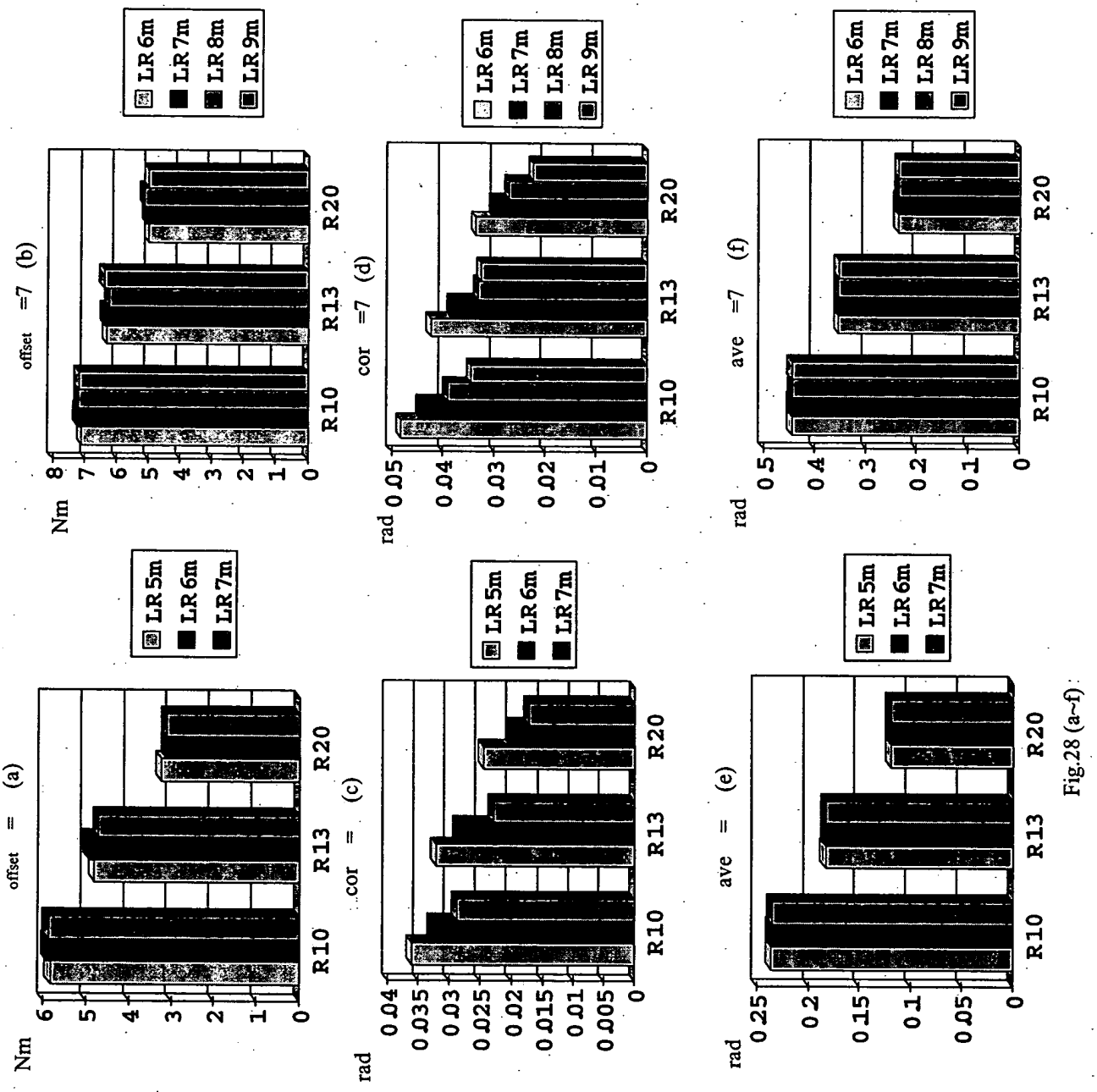

offset = (a)
Nm
LR5m
LR6m
LR7m
R10
R13
R20
offset =7 (b)
Nm
LR6m
LR7m
LR8m
LR9m
cor = (c)
rad
cor =7 (d)
rad
ave = (e)
rad
ave =7 (f)
rad

Fig.28 (a~f)

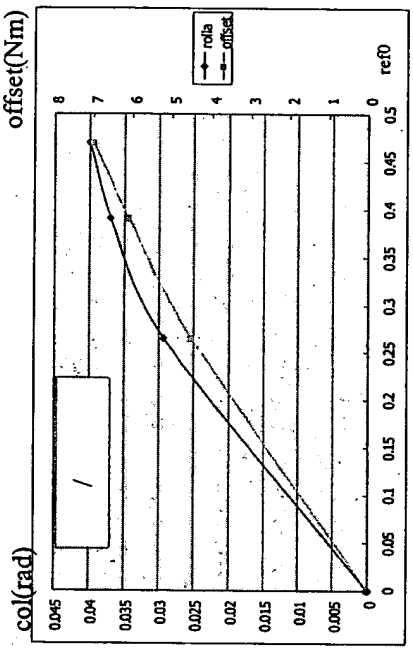


FIG 29B

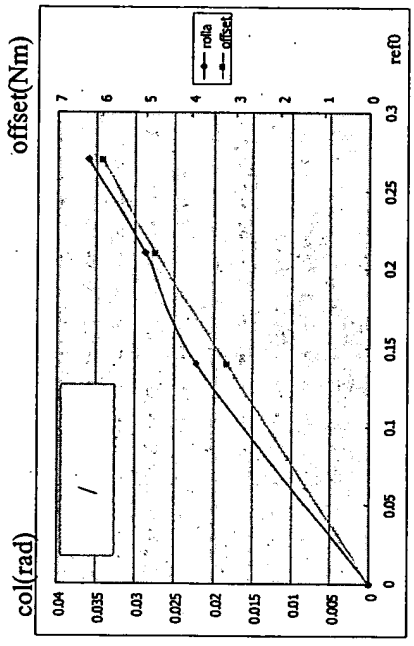


FIG 29A

Fig.29(a~b from left)

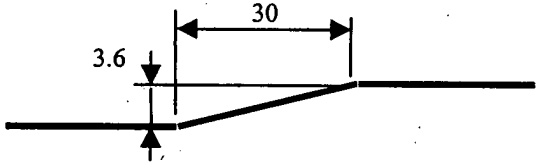


Fig.30 (a) Course of lane change

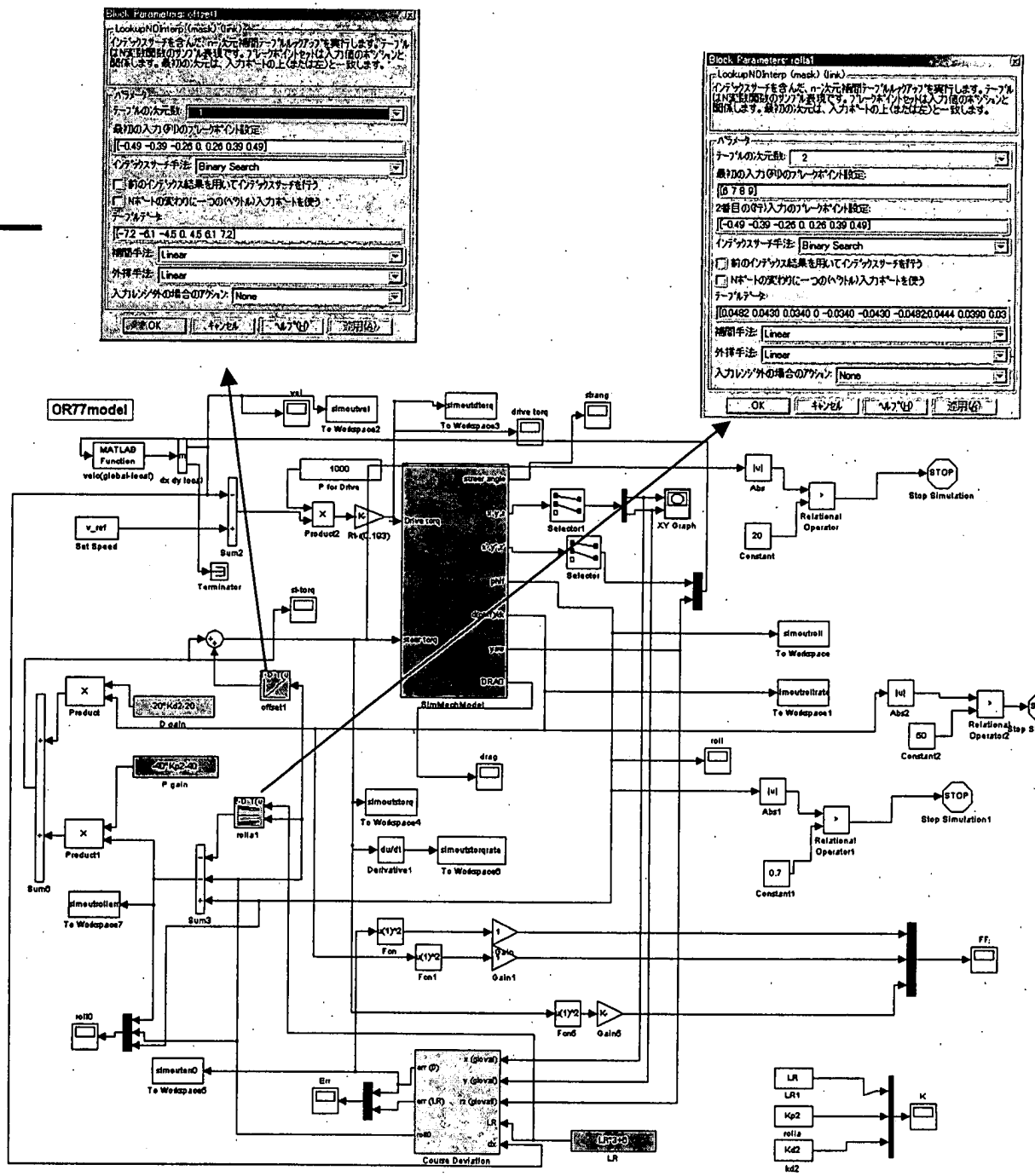


Fig.30 (b) Model for lane change simulation

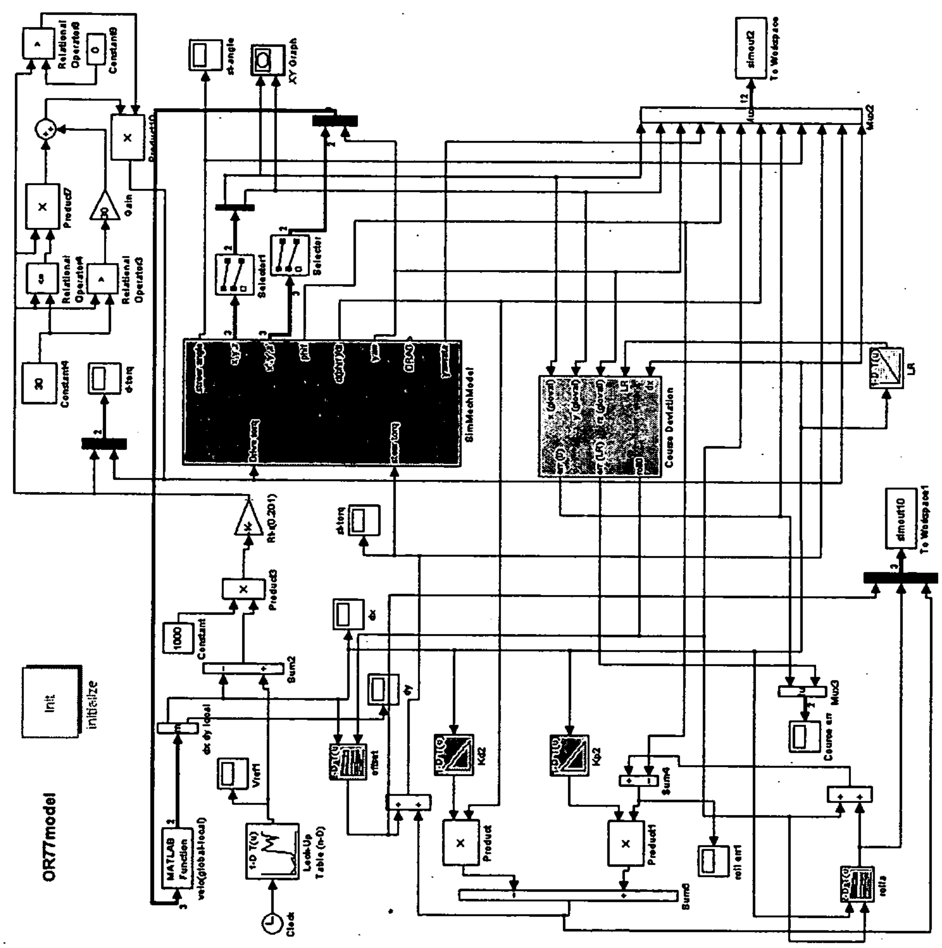

OR77model
Init
initialize
Clock
MATLAB Function
SimMechModel
Course Deviation
XY Graph
simout2
To Workspace
simout10
To Workspace1
1000
Constant
Sum2
Product
Product1
Sum4
Sum5
Gain

Fig.31

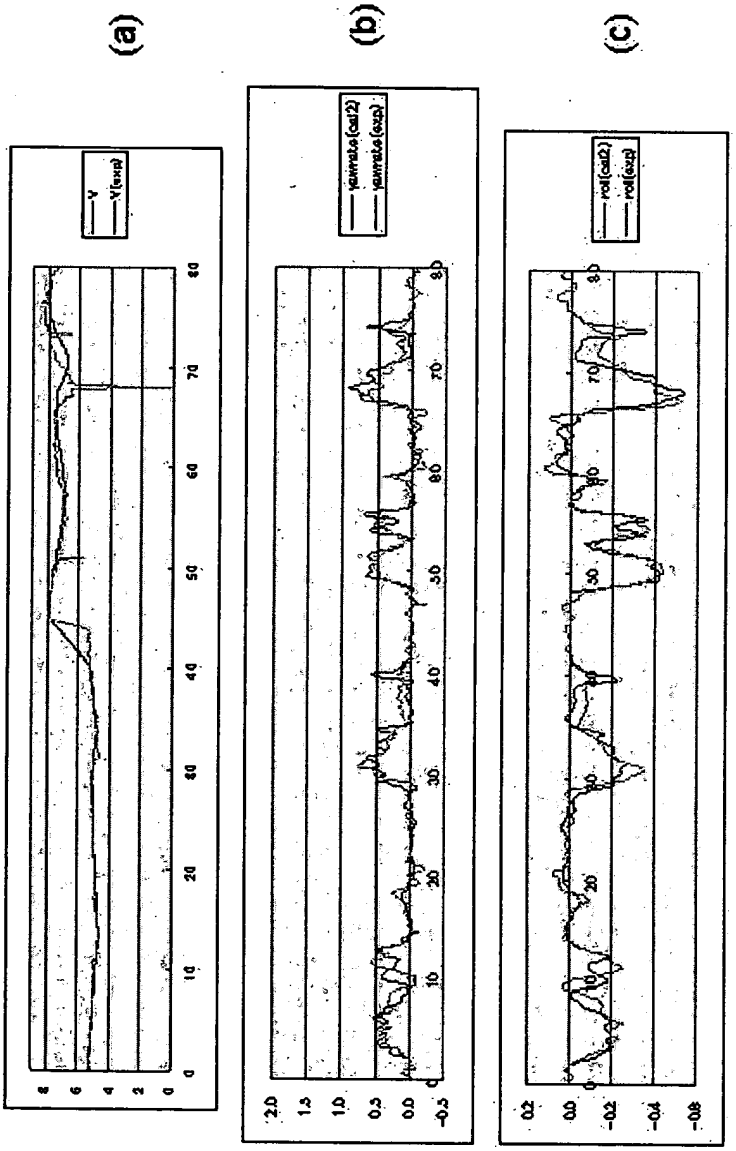


Fig.32 (a~c from above)

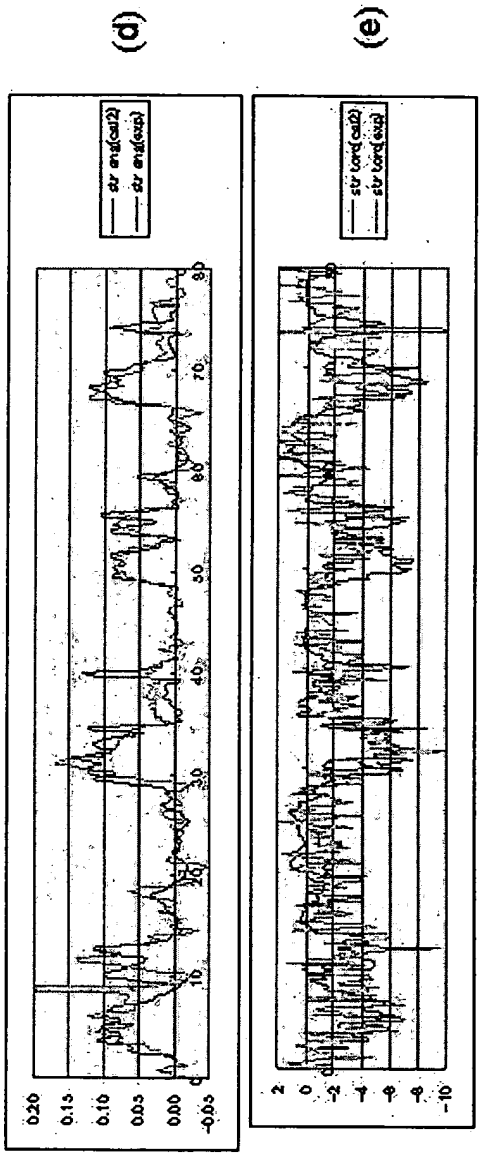


Fig.32 (d~e from above)

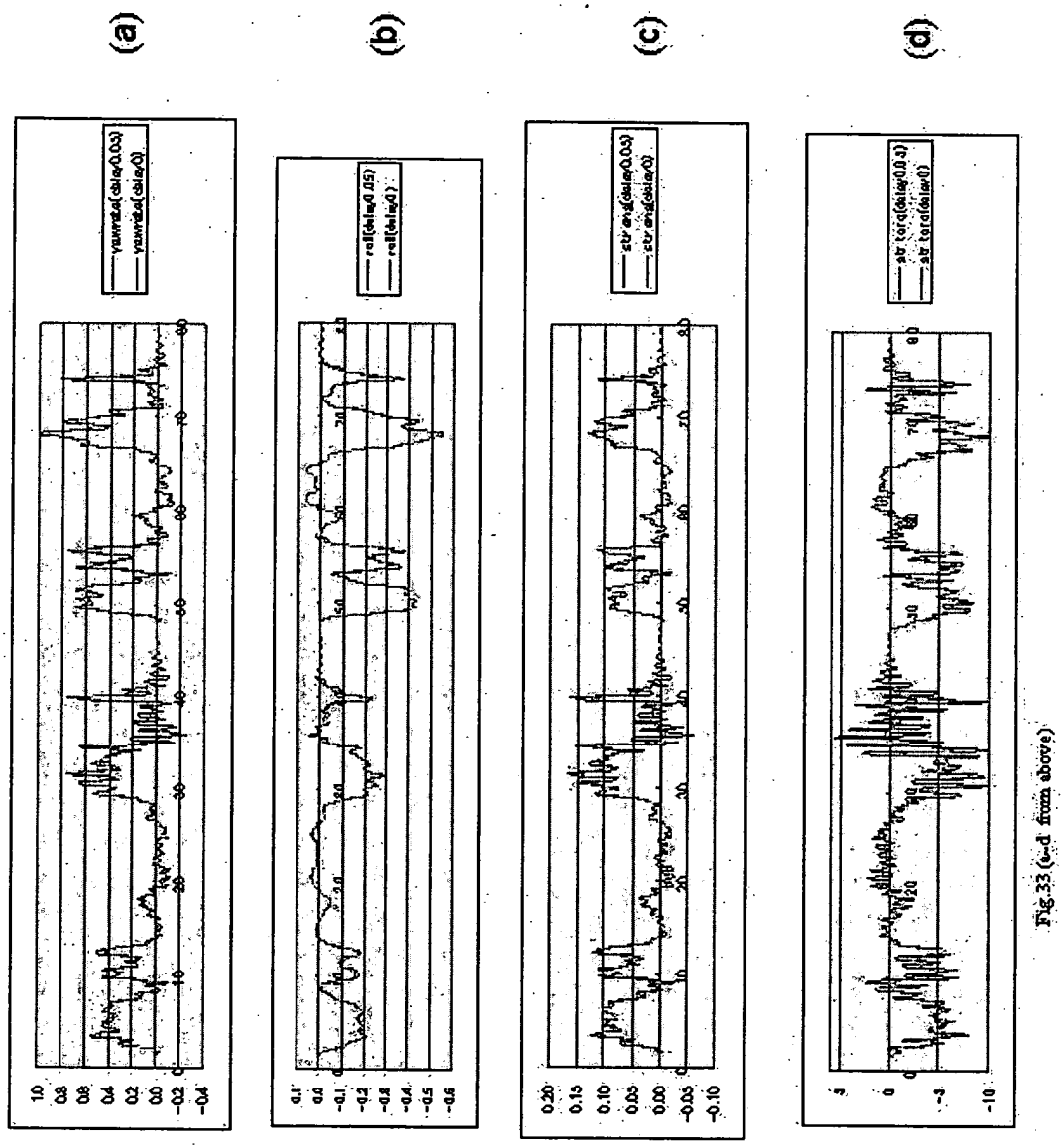


Fig.33 (a-d from above)

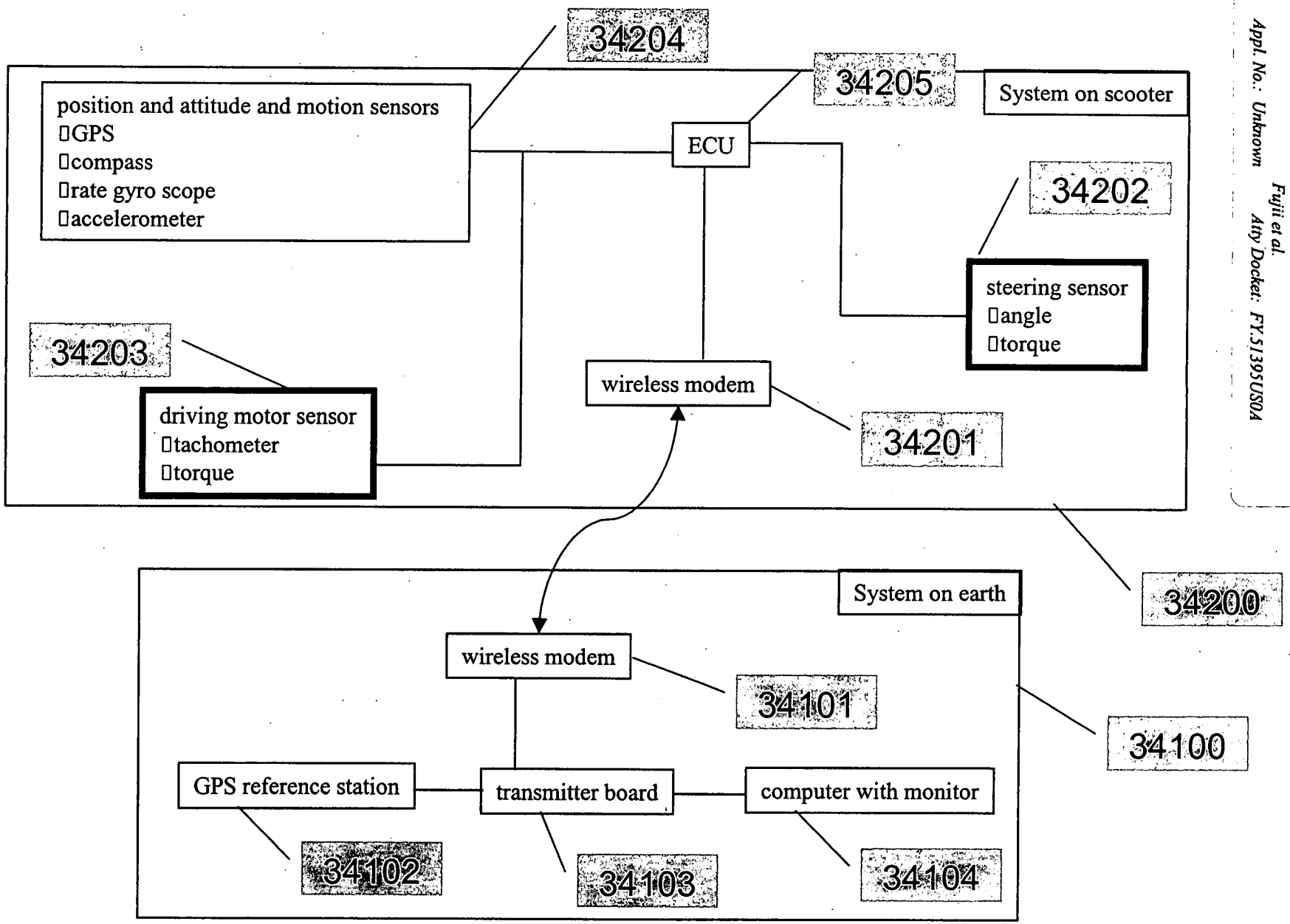

34204
34205
System on scooter
position and attitude and motion sensors
GPS
compass
rate gyro scope
accelerometer
ECU
34202
steering sensor
angle
torque
34203
driving motor sensor
tachometer
torque
wireless modem
34201
34200
System on earth
wireless modem
34101
34100
GPS reference station
transmitter board
computer with monitor
34102
34103
34104

Fig.34

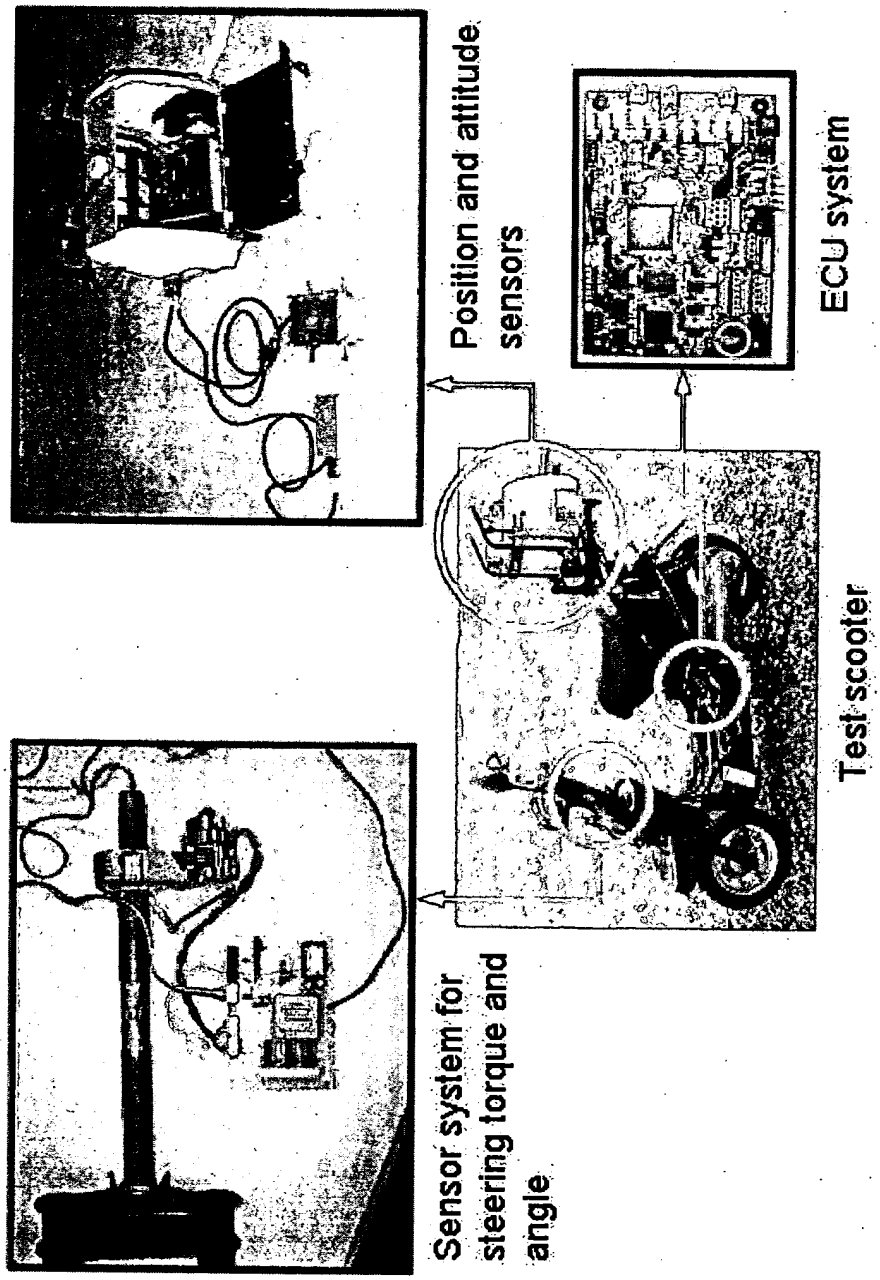
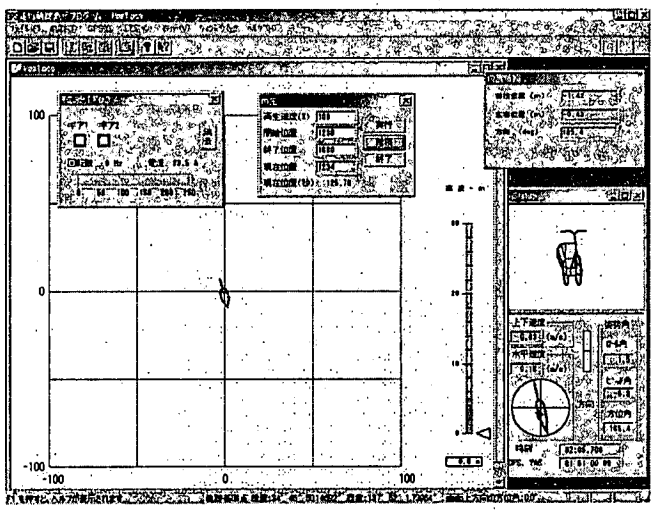
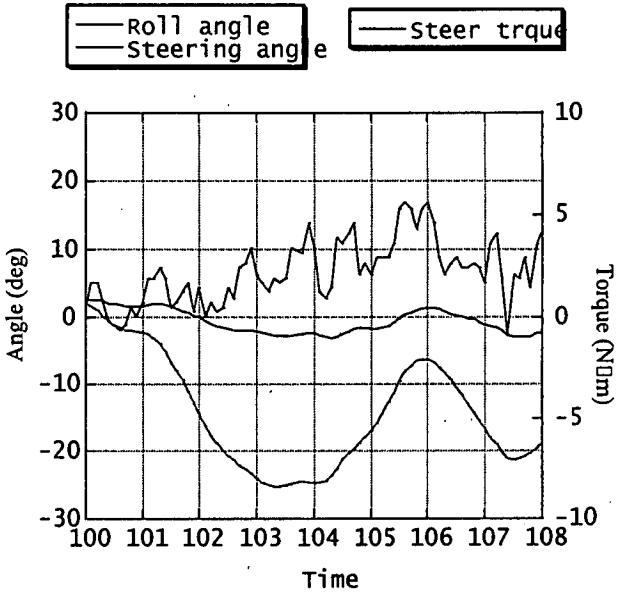

Position and attitude sensors
ECU system
Test scooter
Sensor system for steering torque and angle

Figure 35



(a) Realtime monitor of position and attitude



(b) Measured data

Figure 36